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POWER

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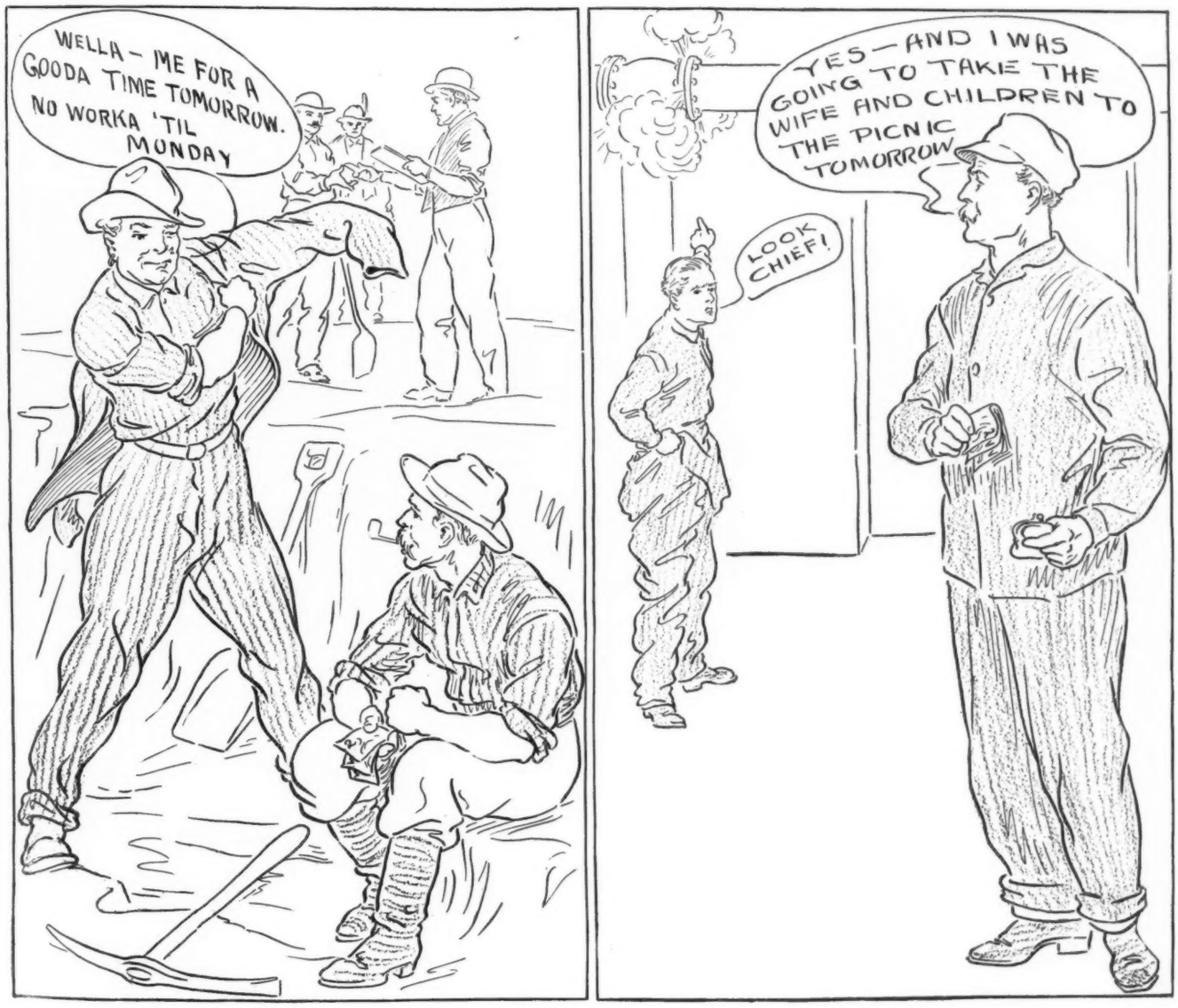
WELLA - ME FOR A GOODA TIME TOMORROW. NO WORKA 'TIL MONDAY
YES - AND I WAS GOING TO TAKE THE WIFE AND CHILDREN TO THE PICNIC TOMORROW
LOOK CHIEF!

WHERE THE DAY LABORER HAS IT ON THE ENGINEER.

Power from the Mississippi River

SYNOPSIS—Three hundred thousand horsepower obtained at Keokuk by a dam, creating 32 ft. mean head, and Francis-type turbines of 86 per cent. efficiency. Power is transmitted as far as St. Louis, 144 miles distant, at 110,000 volts.

The average person thinks of the Mississippi River as a sluggish stream of muddy water flowing evenly its 2500 miles to the sea. Of such a stream one would scarcely suspect water-power possibilities, for when thinking of water power it is natural to picture a majestic fall, as at Niagara or Snoqualmie, or a plant with an Alpine set-

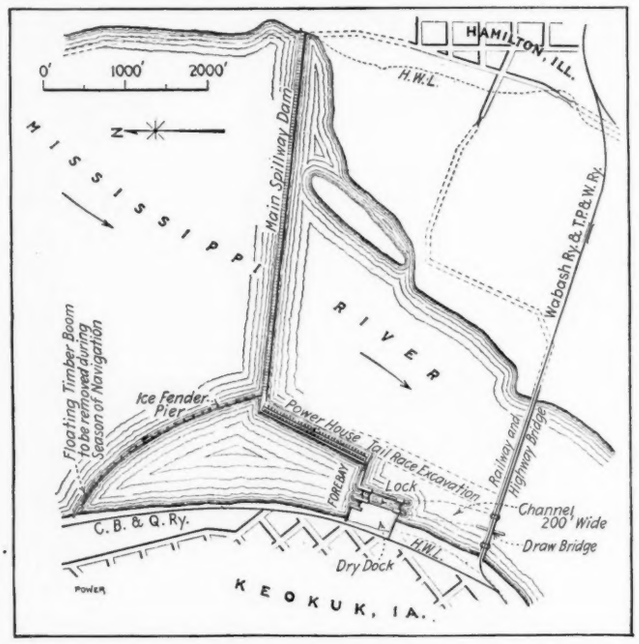

FIG. 1. MAP OF DAM, POWER HOUSE, DRY DOCK AND LOCK

ting, everlasting mountains forming a background. Yet, on the Mississippi, at Keokuk, Iowa, the Mississippi River Power Co. has erected and just put into operation a water-power plant of distinguished proportions and noteworthy features with a power output by far the largest in the world.

Ultimately, this plant will have a capacity of more than 300,000 hp. or over 231,000 kw. This vast amount of energy is to be obtained by making the greatest river in North America pass a large share of its 20,000 sec.-ft. minimum flow, or 372,000 sec.-ft. maximum, through 30 turbine-obstructed concrete tubes, 18 ft. in diameter, in a power house 1718 ft. long; or approximately one-third of a mile.

For about 12 miles up river from Keokuk the Mississippi forms what are known as the Des Moines Rapids, the total descent of the river in that distance being about 23 ft., or greater than that for any similar stretch elsewhere in the river. Added to this essential—an appreciable fall within a comparatively short stretch—the location offered the advantage of bluffs close to the river on both sides for a considerable distance above the dam site, thus reducing the area overflowed by the erection of the dam. And finally, the river bed was found to consist of blue limestone of excellent quality, thus providing an excellent natural foundation for the dam, power house, etc.

A government canal extending nine miles around the lower part of the Des Moines Rapids served heretofore to assist boats past this turbulent stretch of water. With the completion of the dam this canal and its set of three locks was inundated by several feet of water. Some of the conditions imposed by the national government before permission was given to build the dam and power house were that navigation should not be interrupted and that a lock, to take the place of the now useless canal and locks, and a dry dock, be provided by the company, together with the necessary motive power in perpetuity to operate lock, dry dock and the machine shop connected with the latter.

Thus, it comes about that integral with the dam and power house are one of the largest locks in the world and the largest dry dock in fresh water. These were designed and constructed under the scrutiny of war-department engineers and upon completion were turned over to the United States without cost.

The erection of the dam causes the formation of a pool or lake, from 1 to 3 miles wide, for 65 miles above the dam, with a depth at its lower end of over 40 ft. and at its upper end, 8 ft. The substitution of one large lock for the three smaller ones and the elimination of the canal, in the passage of which boats were compelled to proceed at low speed, have reduced the steaming time between Keokuk and Montrose by about 2 hr., a gratifying development to river men.

THE DAM

In Fig. 1 is given a diagrammatic plan of the work while a panoramic view is offered in Fig. 2. The dam, stretching practically out of sight across the river, looks more like a heavy masonry or concrete bridge. And, in actuality, that is what it is—a series of massive piers connected at the top by a causeway. What makes a dam of it are the thick webs of concrete rising 32 ft. between the piers at the bottom with adjustable steel gates above which hold back the water and create a difference in level of from 29 to 41 ft., depending on the condition of the river and the position of the gates.

The dam, of the gravity type, maintains its stability against the pressure of the water by sheer weight alone, and is of massive concrete without reinforcements.

The length of the dam is 4278 ft. which, with a 290-ft. abutment at its east and an 81-ft. abutment at its west end, makes a total of 4649 ft., or 88 per cent. of one mile. There are 118 piers, 6 ft. thick and 53 ft. high. At the top, these are 29 ft. wide and at the bottom 42 ft.; all the taper is given to the down-stream faces, the up-stream ones being plumb. The distance between piers is 30 ft. in the clear. The arched causeway across the top is 29 ft. wide. This may be used as a double-track railroad bridge, if desired, by making a short connection with the shore at the west end.

The normal depth of the river being about 7 ft., cofferdams were employed for all parts of the work as the cheapest means of construction. Some preliminary statistics and views were given in POWER for Sept. 5, 1911.

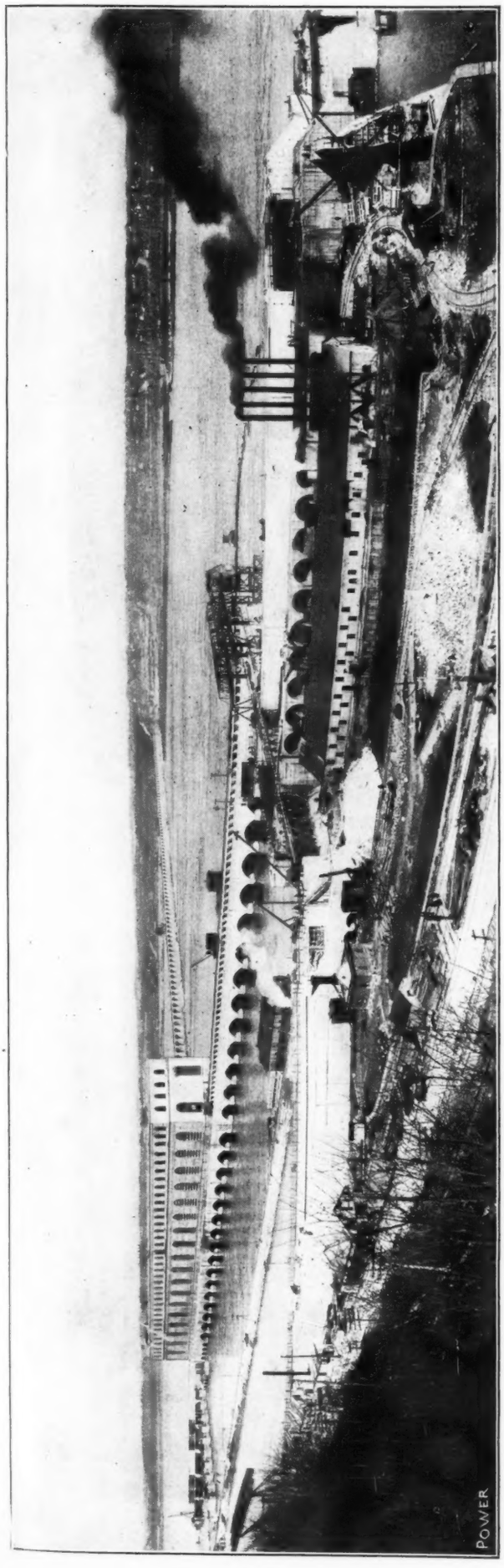

FIG. 2. PANORAMIC VIEW OF DAM, POWER HOUSE AND THE PARTLY COMPLETED DRY DOCK AND LOCK

The power house, lock and dry dock are located in the river close to the Iowa shore. The power house lies practically parallel with the river and nearly at right angles with the dam. The area between the power house and the Iowa shore serves as the forebay, the down-stream end being composed of a short dam wall, the lock and the dry-dock area, as shown in Fig. 1.

At the opposite end of the forebay a concrete ice fender extends 2625 ft. from the dam to the shore. A 300-ft. break in this fender is provided near the shore to permit the passage of boats to and from the dry dock and lock. In the ice season, this break is closed by a floating boom, so designed as to have a draft of 5 ft., thus effectively obstructing even an extensive floe of ice or mass of drift wood. The concrete portion of the ice fender is composed of piers 10 ft. thick on 70-ft. centers, connected at the top by concrete spans extending 4 ft. below the mean low-water level and 5 ft. above the mean high-water mark.

Owing to the vast amount of work and material involved in the erection of this plant, and, hence, the huge sum of money required, speed in construction was of cardinal importance for the sum representing the interest on the money expended for prosecuting the work kept growing in ever increasing proportions. For this reason it was good business to make the most elaborate preliminary arrangements and provide an ample and efficient construction force and equipment to insure rapid work.

The work was carried on in two sections. One force started the dam at the Illinois shore and worked west to connect with the power plant which, with lock, dry dock and ice fender, was erected simultaneously with the dam by another force.

The first 36 spans of the east end of the dam were built on a meadow intervening between the normal shore of the river and the bluffs and for these no coffer-dam was needed. Coming to the river, a sectional coffer-dam 78 ft. wide was constructed, as required, the first section to be put down being about 1000 ft. long. Subsequent sections ranged in length from 400 ft. up. A complete pumping plant containing two 6-in. centrifugal pumps of about 1000 gal. per min. capacity, was used for pumping out the various sections of coffer-dam-inclosed area.

The first operation in constructing the dam was to blast out a slot in the bed rock floor of the river several feet deep and as wide as the base of the dam itself in which the solid concrete work of the huge monolithic structure was commenced. Thus, the dam was firmly keyed in position. Next, the solid concrete piers and overhead connecting arches were "poured" into their steel molds. As a section of the concrete hardened, the forms were removed and used again. A partition wall was thrown across the coffer-dam between the finished and unfinished work and the section of coffer-dam thus rendered unnecessary would be destroyed. Coffer-dam material was economized and the least possible obstruction was made to the flow of the river, the spaces between the piers being left clear for the water to flow through.

On the site of the power house, dry dock and lock a large coffer-dam was put down and pumped out, unwatering an area of 35 acres. After the completion of these structures the work of building up the dam between the piers was commenced. This was done by first putting

down what are known as stoplogs so that the space between a pair of piers was closed off and could then be pumped out. Next, the concrete for the web between the piers was poured into position, and, although the completed height of this web is 32 ft. above the river bottom, a layer of only 5 ft. was put down at one time and the space between, only one pair of piers was blanked off. In this way the dam was gradually built up with

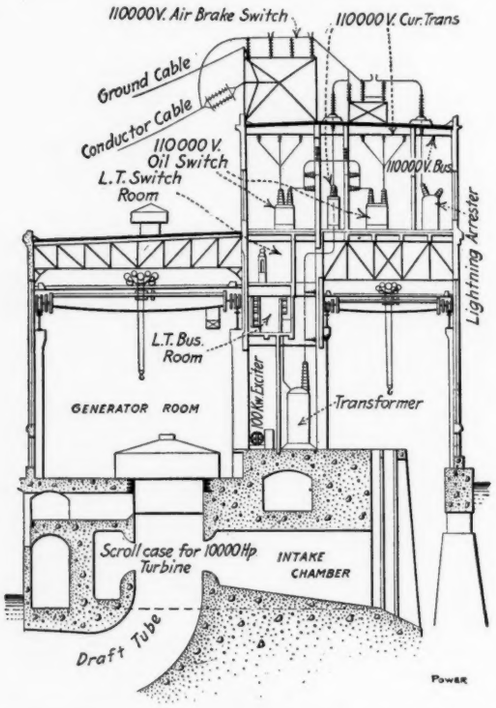

FIG. 3. DIAGRAMMATIC CROSS-SECTIONAL ELEVATION OF THE POWER HOUSE

the minimum of resistance from the river. The up-stream face of this web is vertical, but the down-stream side has the form of an ogee curve so that water running over the crest of the dam will do so with the least noise and disturbance.

LOCK AND DRY DOCK

The lock and dry dock are built integral with the power house and dam. The former has the same width as those in the Panama Canal, 110 ft., and is 400 ft. long inside the chamber. The dry-dock basin is 150 ft. wide by 463 ft. long.

The lower gates of the lock are 50 ft. high, providing for a maximum lift of 40 ft. in contrast with a 32-ft. maximum at Panama. They are hinged at the sides and swing inward in the usual manner.

The upper gate is of special design and of a type that raises and lowers. Its lower portion consists of a rectangular steel box open on the bottom for the admission of water; the upper portion is a framework of structural steel faced on both sides with plates which join the box part at the bottom and are water-tight at their joints, thus forming the actual gate surface. This gate fits into a slot and is provided with rack and pinion at each side, the pinions being connected by a shaft extending across the gate, to prevent jamming due to uneven raising or lowering. To raise the gate, air is forced into the lower part which drives the water out through the bottom. In lowering, the operation is reversed, the air being released by changing a set of valves. A second or guard gate is provided for emergency use. These two and a third gate, employed in the dry dock, are interchangeable and so arranged that they can be easily floated from one position to another when desired. With the lock gate in its lowered position there is a clearance of 8 ft. of water above it which is ample for any boat on the river.

POWER HOUSE

Only 859 ft., or half of the power house, has been completed. The other half will extend from the present half down stream almost to the lock, which is seen in partly completed condition at the right in Fig. 2. The width of the power house is 132 ft. 10 in., and the height, including the under-water section, 177 ft. 6 in. What is known as the substructure portion, containing the intake tubes, turbines and draft tubes, is 70 ft. high from the bottom of the foundation to the dynamo floor. The foundation extends 25 ft. below the river bottom and is set in an excavation in the solid limestone. The superstructure contains three floors for transformers, busbars and switches. The diagrammatic cross-section in Fig. 3 shows the general arrangement of the apparatus. The substructure is of solid concrete; the walls are of rein-

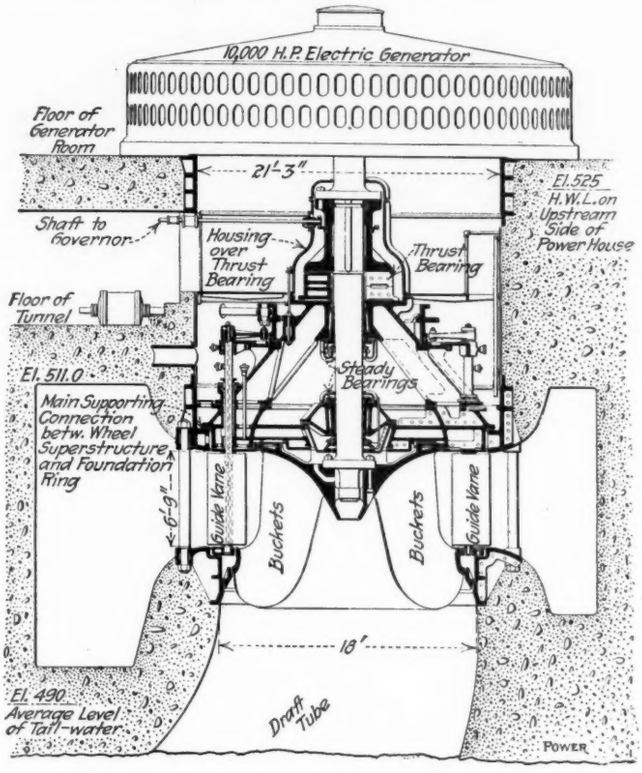

FIG. 4. VERTICAL SECTION THROUGH ONE OF THE UNITS

forced concrete and the floors and roof are of structural steel and reinforced concrete.

GENERATING EQUIPMENT

The present generating equipment consists of 15 Francis-type turbines nominally rated at 10,000 hp. driving 7500-kw. vertical dynamos. In the completed power house there will be 30 such units. A general interior view of the dynamo room is given in Fig. 5.

The turbines are of special design, being unusually large and operating under unusual conditions. Half were

FIG. 5. INTERIOR OF GENERATOR ROOM JUST BEFORE THE FIRST UNITS WERE READY TO BE STARTED

built by the I. P. Morris Co. and half by the Wellman-Seaver-Morgan Co. The best practice and knowledge on water turbines of Norway, Switzerland, Germany, France, Italy and America were drawn upon in designing these turbines, and, as a result, an efficiency of 86 per cent. by Holyoke test has been attained. This is exceedingly high, in fact, it is claimed as a world's record. The usual efficiencies range between 75 and 80 per cent.

While the normal actual capacity of each turbine is a little over 10,000 hp., the overload rating is 13,000 hp. These values are based on a head of 32 ft. and a speed of 57.7 r.p.m.

The runner is 16 ft. 2 in. in outside diameter and carries 20 blades, 6 ft. long by about 3 ft. wide. It is hung on a 25-in. shaft which passes up through the generator floor and carries the rotor of the dynamo on its upper end. A single huge thrust bearing is located between dynamo and turbine, as shown in Fig. 4, to support the entire weight of the revolving parts, some 550,000 lb. Below are two steady bearings to hold the revolving parts in position. All bearings are above water, making them easily accessible and simplifying the problem of lubrication. The thrust bearing is of the roller-bearing type and is provided with means of forcing a sheet of oil between the two faces at a pressure of 250 lb. per sq.in. to float the load and obviate the need of the rollers. An attempt will be made to operate without the high-pressure oil, using the rollers only. If this proves successful and economical, the oil will be used only in emergencies.

A set of guide vanes, surrounding the runner and connected with two oil-operated pistons, adjusts the water supply to the runner in accordance with variations in electrical load and hydraulic head. The movement of these vanes is controlled by a Lombard governor. A cross-section showing the general construction and arrangement of each unit is given in Fig. 4.

There are four water-inlet passages, Fig. 6, to each turbine, three of which unite a short distance from the inlet to form the larger portion of the scroll chamber, the fourth forming the remaining portion. Each passage is fitted with headgate and screen. The shape and dimensions of these water passages and the scroll chamber were carefully planned so as to deliver the water to all points on the circumference of the turbine at a uniform velocity, thereby securing maximum efficiency.

The draft tube is 18 ft. in diameter at the point where the water leaves the runner and gradually changes in shape until it is an oblong rectangle with circular ends at the point of discharge to the tailrace, 22 ft. 8 in. high and 40 ft. 2 in. long. The entrance velocity of the water is 14 ft. per sec. and the discharge to the tailrace 4 ft. per sec. The turbines are placed 22 ft. below the mean

level of the forebay; thus, 10 ft. of the head is utilized by means of the draft tube.

Dynamos

The main dynamos are of the General Electric revolving-field vertical type and generate 25-cycle, three-phase current at 11,000 volts. The current is distributed at this pressure for local use, but for long distance it is stepped up to 110,000 volts. Because of their low speed the dynamos are of great size, being 31 ft. 5 in. outside diameter with a height of 7 ft. 2 in. at the lowest part.

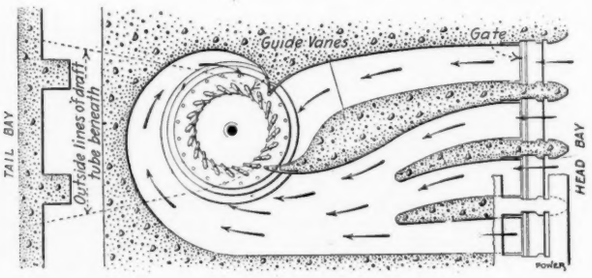

Fig. 6. Plan of Inlet Passage and Scroll Chamber

The efficiency of these generators is 96.3 per cent. at full load and their regulation is 13 per cent. at 100 per cent. power factor. Each machine is fitted with a brake to facilitate bringing the revolving parts to rest when shutting down.

The method of excitation is somewhat unusual. Two 2000-kv.-a. alternators driven by water turbines of the same general design as the main turbines will furnish excitation current for the 30 main generators in the completed station. These feed 25-cycle current at 440 volts to three-phase busbars running the length of the station. From these busbars a 100-kw. motor-generator set is operated for each main dynamo supplying it with current at 250 volts.

For emergency, another 440-volt bus has been installed for each group of 15 units, supplied from the main power busbars through two 600-kv.-a. transformers and all of the motor-generators are arranged for connection with this bus. The voltage of each main generator is controlled by a Tirrill regulator connected with the field of the exciter.

Busbars and Switches

Both high- and low-tension busbars are in duplicate and all dynamos, transformers and lines are equipped with selector switches so that they may operate from either bus. One low-tension bus extends unbroken the full length of the station and is to be used for transferring and in emergency. The other bus, which will be used for normal operation, is fitted with sectionalizing switches and current-limiting reactances so that each outgoing line will be fed from a separate group of dynamos and transformers. Normally, all sections are paralleled through the reactances and the emergency bus joins the ends of the main bus to form a ring.

In addition, there is a low-tension bus for the local 11,000-volt feeders. Fig. 7 shows the general arrangement and construction of the low-tension bus compartments.

Except those for the low-tension bus sections, all switches are nonautomatic and arranged so that trouble in one section causes the opening of the two nearest section switches and through a relay on the voltage regulators, a reduction of the generator voltage.

The emergency and transfer high-tension bus is divided into sections, one for each line. The other is similarly arranged but equipped with section switches so that, if desired, the sections may be paralleled.

The connections between the generators and the low-tension bus room, which is on the second floor, consist of 600,000-circ.mil, single-conductor cables insulated with varnished cambric. The busbars and the current and potential transformers are housed in concrete compartments.

The low-tension switches are directly above the busbars and are also inclosed in concrete cells. These are General Electric H-6 oil-break type, fitted with disconnecting switches in subcells. Connection is made between these switches by solid bars either directly with the busbars or through instrument transformers with the generators and main transformers.

The low-tension circuits are guarded from internal voltage surges by electrolytic static dischargers connected to the various sections. Protection from excessive current is secured by the sectionalization previously mentioned which divides the equipment into ten groups. Connection between these groups is made through current reactances rated at 240 kv.-a. These reactances consist of copper cable wound about three large concrete cores, making a total weight of about 27,000 lb.

Cables similar to those between dynamos and low-tension busbars connect the latter with the transformers which are arranged in a row opposite the generators and on a gallery 8 ft. above the generator-room floor. The

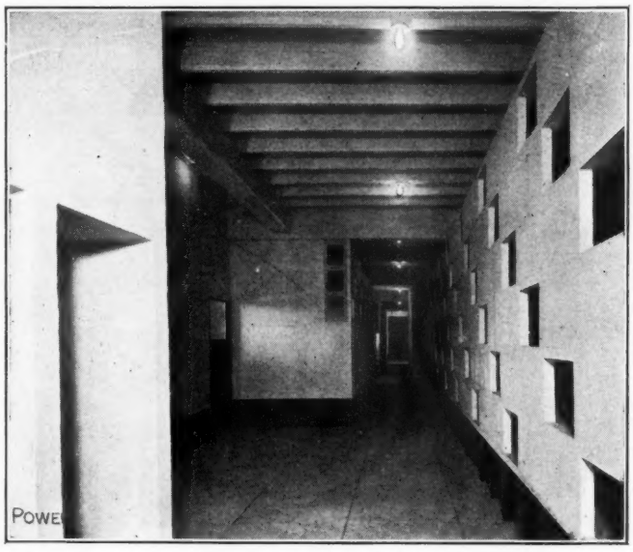

Fig. 7. Low-Tension Bus Compartments

transformers are for three-phase, 25-cycle, 11,000-110,000-volt service and rated at 9000 kv.-a. On the low-tension side they are connected delta and on the high-tension, Y, with the neutral dead grounded. Each transformer is set in a concrete compartment and occupies a space about 8 ft. wide by 16 ft. long and 24 ft. high. The weight is 231,000 lb. each and 10,000 gal. of oil is required.

High-Tension Connections

The connections from the transformers to the high-tension busbars and switches, which consist of 1¼-in.

standard iron pipe, extend vertically to the top floor where the busbars and switches, Fig. 8, are located. These connection pipes are painted copper color for psychological reasons.

The high-tension switches are General Electric K-15 type, triple-pole solenoid operated and of 400 amp. capacity. They are provided with disconnecting switches on one side only, being attached directly to the high-tension busbars on the other.

The high-tension busbars are installed individually in separate rooms and run the full length of the building. These busbars are of 2-in. standard iron pipe hung from the ceiling by seven-unit suspension insulators. The connections from the busbars to the current transformers are of 1¼-in. copper pipe. From the transformers the connections pass directly up through the roof bushings. The latter are of special design and afford a factor of safety of three under rain test with line voltage and four when dry.

From the roof bushings the lines run through choke coils to an air-disconnecting switch of the rotary double-break type, mounted 24 ft. between phases and with arms 12 ft. long. Taps to the lightning-arrester horns are made between the choke coils and the disconnecting switches. The horns are connected through roof bushings with electrolytic arrester tanks inclosed in concrete compartments on the top floor of the building.

Switchboard

The switchboard, Fig. 9, is located in a room on the top floor at a point which will be the middle of the building when the latter has been completed. The board is of the remote-control bench type with instrument panels arranged behind the bench. There is a panel of both

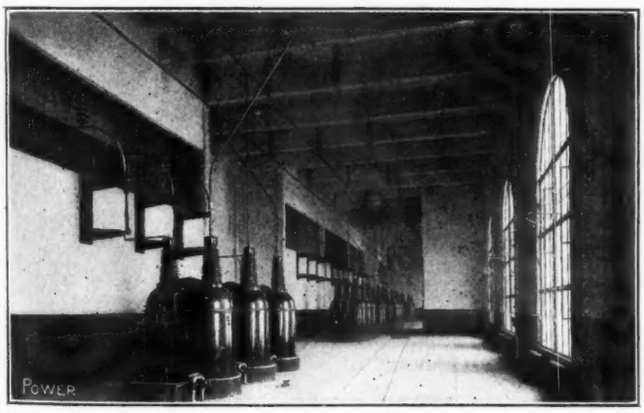

Fig. 8. View of High-Tension Switches and Busbars

bench and instrument board for each main generator and transformer unit and each outgoing line as well as for the exciters.

With the complete equipment in place the board will form a huge U, extending around three sides of the room. In the center of the room is the chief dispatcher's desk and a switchboard. The desk is fitted with a telephone-exchange board and telephone-testing equipment so that complete control is had over the entire telephone system. The switchboard carries a diagram of the bus arrangements and the position of every switch in the station is shown by means of colored lights. In addition, this board is equipped with graphic voltmeters and ammeters for recording the potential and current for each transmission line.

Two storage batteries of 320-amp.-hr. capacity, each, are provided for furnishing the motive power required in the switchboard room. For charging these batteries two 15-kw. motor-generator sets have been provided.

The telephone system is especially complete and provides means for rapid communication with all possible points throughout the station as well as with all substations and points of distribution. Besides the telephone system a signaling system is provided for transmitting the more common operating instructions from switchboard room to each generator unit.

Huge windows spaced on short centers provide ample

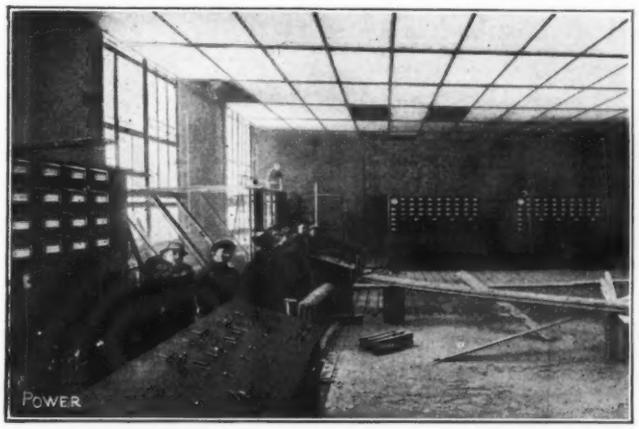

Fig. 9. Switchboard Room Partly Completed

natural light in the main rooms. The artificial light is furnished entirely by tungsten lamps backed with steel reflectors. The lighting current may be taken from either the main low-tension busbars or from the exciter bus through suitable transformers and induction regulators. Approximately one-third of the lights employed throughout the station are so wired that in the case of either under or over voltage they are automatically thrown over onto one of the storage batteries, either of which has capacity for about one hour's service.

The generator room is equipped with two 150-ton traveling cranes and the gate house with a 75-ton machine.

Distribution

For local consumption the current is distributed at 11,000 volts, but for long-distance transmission the current is stepped up to 110,000 volts as before mentioned. Two long-distance lines carried on a single set of towers, Fig. 10, have been run to St. Louis, 144 miles distant, where 60,000 hp. has been contracted for. These lines are of 36,000 kw. capacity, each. Two 27,000-kw. lines have been built to Burlington.

The larger lines, those to St. Louis, are of ⅝-in. copper cable, of 300,000 circ.mils. These cables are carried on towers averaging 80 ft. high, spaced on 800-ft. centers, by means of suspension-type insulators, each consisting of seven 10-in. disks. These disks are of porcelain and corrugated on their faces. They are strung together by means of malleable-iron fittings cemented to them. This type of insulator was selected after a large number of comparative tests of various types and it possesses a fac-

tor of safety greater than that employed on any other transmission system of equal voltage. The required voltage test is against 440,000 volts.

Price of Current

The Mississippi River Power Co. will sell current only at wholesale in quantities of 100 hp. or more. The announced policy of the company is to encourage manufacturers to locate plants in the section and, hence, a uniform rate of charge for its power is provided for all who use it, regardless of whether the current is purchased direct or through a third party. The maximum demand or service charge is 75c., net, per month per horsepower. Then, the charge for the first 8000 kw.-hr. per month is 1½c. per kw.-hr. For current in excess of 8000 kw.-hr.

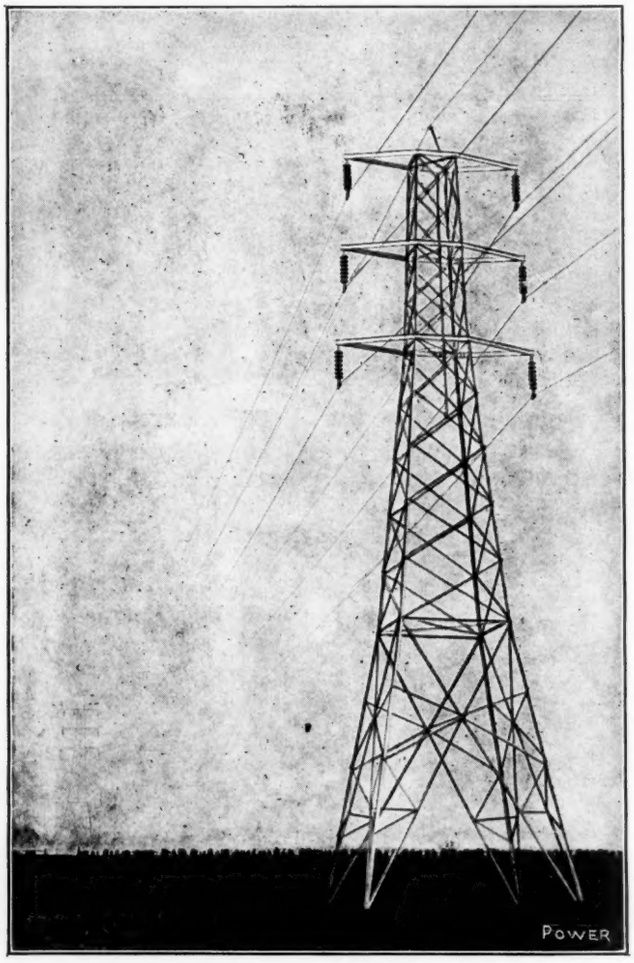

Fig. 10. Typical Transmission Towers

per month the charge is 0.6c. per kw.-hr. A discount of 10 per cent. of the current charge is allowed on all bills paid before the tenth of the month following the month for which the bill is rendered.

The construction of this entire plant, including power house, dam, lock and dry dock, was done by the Mississippi River Power Co. under the personal supervision of Hugh L. Cooper, the chief engineer. No work was sublet to contractors. The Stone & Webster Engineering Corporation, Boston, Mass., had charge of the installation of all the electrical machinery and equipment and the plant is being operated by the Stone & Webster Management Association.

Rules for Boiler Inspection

By J. C. Hawkins

An editorial in a recent issue presents some very good arguments as to why the chief engineer should frequently inspect his boilers and not depend entirely on the insurance inspector.

This has been the writer's practice wherever he had the authority to do so. In one plant which had six water-tube boilers usually loaded to rated capacity, and using a very bad feed water, the boilers were washed every two weeks, but were taken off the line to be thoroughly cleaned and repaired, if repairs were needed, about every three months. At these times the boiler was thoroughly examined. This was done in the following manner:

The fire was drawn, and the main steam valve closed. The feed was left turned on a little until the steam had all worked off. The blowoff cock was left open a little to keep the high-water whistle from blowing. The boiler then stood a day or two full of water with all doors closed. Then the grates and combustion chamber were cleaned, also the tubes and all external surfaces of the boiler. Next the drum was opened, and the scale cleaned off, sometimes it could be scraped off, but usually it had to be chipped off. After the drum was cleaned the turbine cleaner was put through the tubes. Boiler compound was not used. After the cleaning came any repairs that were required. Then came the inspection, which was done by the engineer, according to the following directions:

Put on an extra pair of overalls, and go in on the grates with an electric light, a small hammer and a notebook and pencil. The first thing to be looked at is the tubes to note whether there are any bags or blisters, or any that are worse than at the last examination. Notice whether there is any evidence of leaks around the ends of the tubes or stay-bolts. If any are found, make a note of them in the notebook. Next examine the furnace, side and bridge-walls to determine if any repairs are needed. Then look at the front baffle wall; note if it is in good repair, with all the brick in place. Sometimes the space between the tubes on the back side of a water-tube boiler will be found plugged with ashes; look for this by holding the light above the head so that it will shine between the tubes. Next examine the grates and stoker if there is one. Above all take plenty of time in making the inspection.

Next go in above the tubes under the drum, look for bags on the bottom of the drum, also leaking rivets. Tap them and the tubes with the hammer. Hold the light so that it will shine down between the tubes to permit of examining the baffles, also the brickwork around the drum and at the top of the tubes. Make notes of all defects. The next place is the combustion chamber. Examine the tubes for bags, which seldom are found here, also examine the rear stay-bolts and tube ends for leakage. Examine the blowoff pipe, tapping it hard with the hammer, noting if it is solid. Next come the nipples between the headers and mud drum, if there is one. Clean away the scale and ashes and look for external corrosion and leaks, and then examine the rear baffles, which are usually found all right. That finishes this part of the boiler. Then go in above the tubes at the rear ends, see if the tubes are properly cleaned, look at the tube ends and stay-bolts for signs of leaks, examine the baffle walls, and the damper while the helper opens and closes it.

Look for cracks in the setting, especially around the side doors, also see that the doors shut tight, then examine the front and rear doors for air leaks. Go on top of the boiler and examine the setting. Look for leaky pipe joints and leaky valve stuffing-boxes. The safety valve and blowoff valves should be watched for leaks while in operation. If the safety valve has been leaking, now is the time to regrind or repair it. A leaking blowoff may be found by disconnecting a flange between the valve and blowoff tank, while the boiler is under pressure. Next examine the water column, floats and piping, feed-water regulator, valves and piping, check valves, gage cocks, water-blowoff pipe and valves, etc. This finishes the external surface of the boiler.

Next go inside of the drum, and look for signs of pitting, especially along the water line, also look for scale and corrosion in all parts of the drum. Tap the braces with the hammer to see if they are all tight, examine the mud pan and internal feed pipe to see if they are clear, sometimes the feed pipe will be found nearly stopped up with scale, or it may have become loose in the drum head. See that the dry pipe is in proper position, and that the holes are clear. Examine the opening to the water column and steam gage. Take plenty of time here, as it is very important. Examine the surface-blowoff pipe connection and come out. Then look after the stay-bolts and tubes in the water leg or header. Have a helper hold a light at the front end of each tube while you look through from the rear end to note whether there is any loose scale or if the tube is warped. Reach through the handholes with the hammer and tap each stay-bolt to see if it is solid and tight. Examine the tube-cap joints to see whether or not they are in good condition.

This covers the boiler inside and outside, and includes parts that the insurance inspector would not look at very closely. If the tubes are found dirty, some better way of cleaning them may suggest itself to the engineer while making this inspection. Likewise cracks in the setting may suggest a remedy whereby the CO_2 can be increased, and any needed repairs that have been overlooked can be made at this time.

After getting cleaned up, make some sort of a report of the condition found, mentioning each item, while it is fresh in the mind, and compare it with the report of the last examination. Also make a note of repairs that are likely to be necessary at the next shutdown, and the material may be ordered so that it will be on hand when needed. On the first examination all the dimensions of the boiler should be taken for future reference. This need not be done after that except in special cases.

An examination of this kind every three months will keep the engineer posted on the condition of each and every part of the boiler. It is a dirty job, but will make the engineer's work easier in the end, keep the efficiency of the plant at the highest point and will relieve him of many emergency repairs.

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Automatic Regulation of Superheat

SYNOPSIS—Controlling superheat temperature by regulating the flow of the hot gases.

❖

The temperature to which steam will be raised in a superheater, depends upon the design of the superheater, the amount of tube surface, the number of passes which the steam makes through the surface, the weight of steam passing through the superheater, the volume of hot gases passing over the superheater tubes, and the temperature of these gases. Among the possible methods of controlling superheat temperature are first, to regulate the volume of steam passing through the superheater tubes so that after it has been mixed with saturated steam from the boiler, the mixture will have the desired superheat, and secondly, to regulate the amount of hot gases passing over the superheater tubes, so that the desired steam temperature is obtained for any weight of steam passing through the superheater tubes.

The first method is open to the objection that hot gases are always flowing over the tubes, and, therefore, if no steam or only a small quantity of steam is passing through the tubes they are liable to overheating.

Fig. 1 illustrates the arrangement of Heine superheaters to obtain temperature regulation by controlling the flow of hot gases. This figure also shows the automatic control apparatus. The superheater is located in a firebrick superheater chamber, forming part of the boiler setting, at the side of the boiler drum. The rear of this superheater chamber communicates with the furnace by a flue, through which a small percentage of the furnace gases rise, making two passes over the superheater tubes, and then flowing out to the front at the bottom of the superheater chamber, where a damper is located.

An automatic temperature regulator controls the damper opening, so as to give constant superheat. This automatic regulator comprises two principal parts, a diaphragm lever, actuated by compressed air, and a thermostat controller which regulates the admission of compressed air to the diaphragm lever, in accordance with the temperature of the steam.

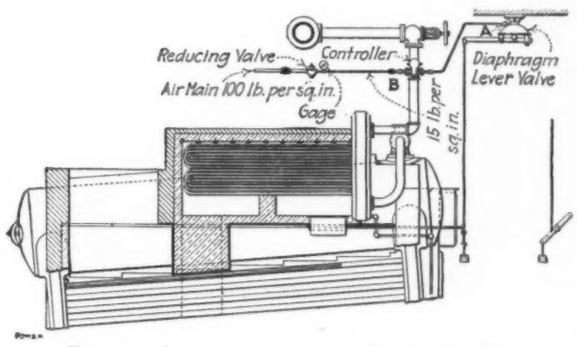


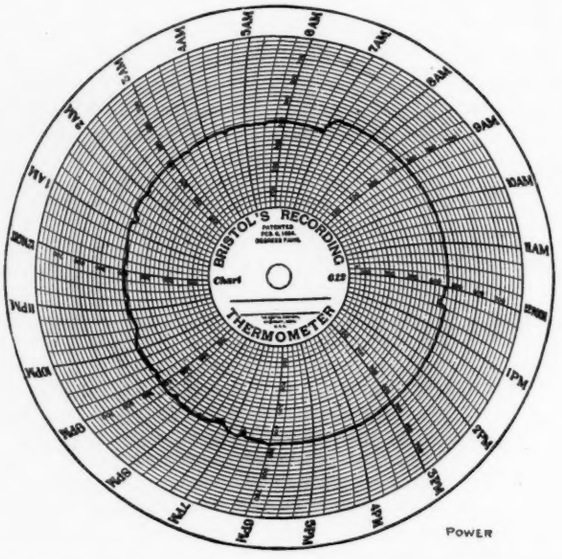
FIG. 1. ARRANGEMENT OF SUPERHEATER

The diaphragm lever in this drawing is suspended from a convenient beam; the outer end of the lever is in line with the damper rod, a link connecting the two. Air enters the top of the diaphragm chamber, which is a convex casting with a rubber diaphragm across the bottom. Springs hold a "saucer" against the diaphragm, the saucer itself being recessed to hold a link connecting with the lever. When there is no air pressure within the

diaphragm chamber, the springs press the saucer against the diaphragm and hold it against the inside face of the diaphragm chamber. When air pressure is admitted, it overcomes the resistance of the springs, and causes the saucer to move downward with corresponding movement of the lever and damper.

The controller for regulating the supply of compressed air to the diaphragm lever is installed in the outlet line of the superheater with a thermostat protruding into a suitable fitting. The thermostat consists of two tubes, one of a metal that changes considerably in length with temperature so that changes in superheat cause changes in relative length of the two tubes. This motion causes changes in the opening of a small ball valve which controls the supply of compressed air to the diaphragm lever.

Fig. 2 tells the history of the performance of an automatic superheater regulator of this type. In this plant the load comes on at 7 o'clock in the morning and as the engines and compressors are started, steam is drawn



Performance of Automatic Superheater Regulator

from the superheater, and the superheat temperature comes up to 460 deg., the setting of the regulator. From then on till noon, the superheat remains constant. From 12 to 12:30, the engines are shut down, and no steam is drawn from the superheater, which is acting simply as additional steam-reservoir space. The automatic temperature regulator closes the superheat damper but the temperature of the steam does not immediately fall to boiler temperature, because of the heat stored in the metal of the superheater and the setting. When the load starts up at 12:30, the temperature immediately rises to the normal of 460 deg. and continues until the end of the working day, 6 p.m. During the night, the boiler is idle, and no steam is drawn through the superheater. The temperature approaches that of the steam in the boiler and the superheater damper is tied shut to positively shut off all gases. During the noon hour and at night, the superheater is not flooded.

An advantage of control apparatus with superheaters is that the temperature may be changed as desired after the plant is installed. The thermostat controller has a small dial and adjusting screw, whereby the mean temperature maintained may be raised or lowered as desired. Thus a plant may be operated for a week or a month at 50 deg. superheat, then 75 deg., 100 deg., etc., operating records being kept at the same time of the load and coal consumed. From these records a determination may be made of the most economical working conditions.

Improved Flow Meter

An improved type of flow meter for the continuous measurement of either liquids, gases or vapors has just been put out by the General Electric Co., of Schenectady.

The body of the meter consists of an iron casting cored out so as to form one leg of a U-tube and a reservoir for mercury, the outer leg of the U-tube being formed by a pipe which opens into the reservoir. The pressure on the surface of the mercury varies with the rate of flow of the fluid being measured, as will be explained later.

A float, Fig. 1, rests on the surface of the mercury in the body of the meter and rises and falls with the corresponding changes in its elevation. This float is geared by rack and pinion to a horizontal shaft which carries a permanent U-shaped magnet, the poles of which face a copper cap inserted between the external case and the meter body. A shaft, parallel to the one on which the magnet inside the body is mounted, carries a smaller magnet whose poles are opposite those of the larger magnet, this arrangement serving to transmit motion through the cap without piercing it with a shaft and thus the difficulty of packing such an entrance to prevent leakage is avoided. As the poles facing one another are of opposite polarity, the magnetic flux binds them together so

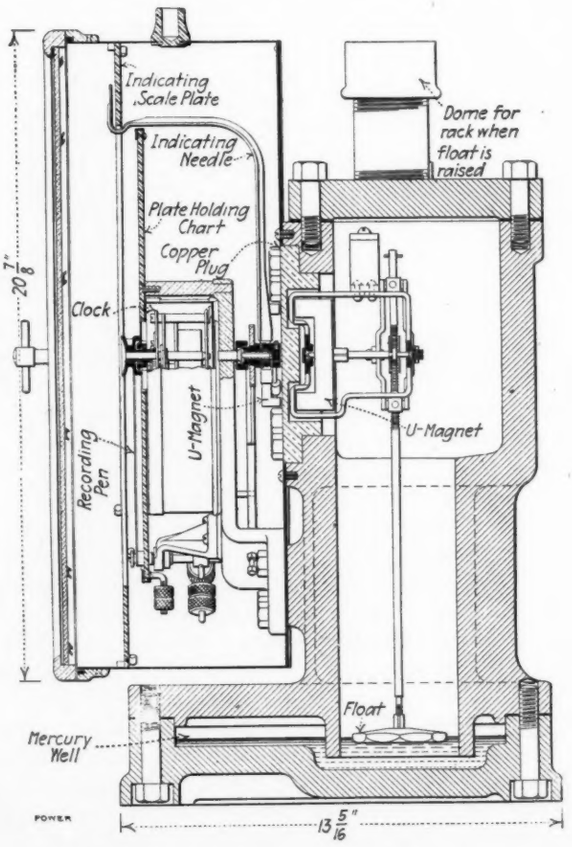


Fig. 1. Section through Meter

that a movement of the magnet inside the body involves a corresponding movement of the one outside, the latter moving the indicating needle and the recording pen through suitable mechanism.

The pressure which moves the column of mercury in the U-tube is obtained, for pipes 2 in. and greater in diameter, by inserting a modified form of pitot tube termed a "nozzle plug" directly into the pipe line, see Fig. 2. This can be done without disturbing the piping, except where it is desired to increase the rate of flow at the point of metering, in which case a special pipe reducer *E* is provided. This reducer is made of brass and has a long throat with rounded entrance terminating in a flange. The flange is inserted between the pipe flanges *A* and *B* and is held in place in the same manner as a gasket. A special nozzle plug is supplied with the pipe reducer.

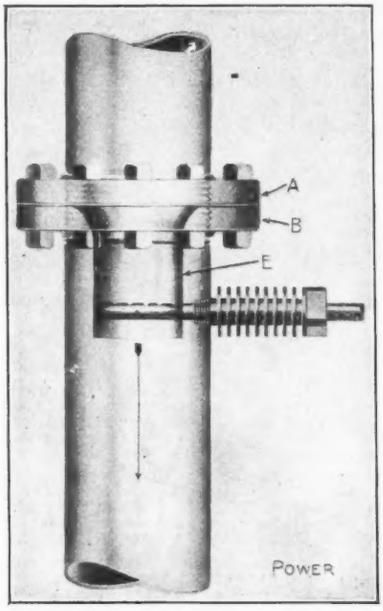


FIG. 2. NOZZLE PLUG

The nozzle plug is a tube with two separate conduits in it, each conduit having a set of openings, the two sets being on diametrically opposite sides of the tubes. Those on the side of the tube facing the flow are called the leading openings, while those on the opposite side are called the trailing openings.

The flow against the leading openings in the nozzle plug sets up a pressure in the leading conduit which equals the static pressure plus a pressure due to the velocity head. The flow past the trailing openings causes a suction which lowers the pressure in the trailing conduit. As these two conduits are connected to the U-tube by ¼-in. pipes, the column of mercury is affected by this unbalanced pressure, causing a movement of the float. The leading set of openings in the nozzle plug extends approximately across the pipe, so as to make the velocity pressure transmitted to the meter the mean velocity pressure rather than that at a single point in the pipe.

The chart on which the pen records are made is rotated by a clockwork at a suitable speed. The recording pen sweeps the chart radially and the resulting curve shows the rate of flow at any time during the chart cycle.

The integrating device consists of a stationary flow-rate planimeter driven by the chart paper. The angular position of the planimeter wheel is determined by a cam connected to the shaft of the recording pen and moving with this pen; the planimeter dials read in arbitrary units, which, multiplied by a constant furnished with the meter, gives the flow in the desired units.

As previously mentioned, for pipes less than 2 in. in diameter an orifice tube, which is a brass pipe tapered internally from both ends so as to form a restricted opening at the middle of the tube, is provided, and it must be incorporated in the pipe line. One leg of the U-tube is connected to the orifice tube near its end and the other leg to its middle point where the greater velocity at the orifice will give a reduced pressure in the pipe leading to the U-tube.

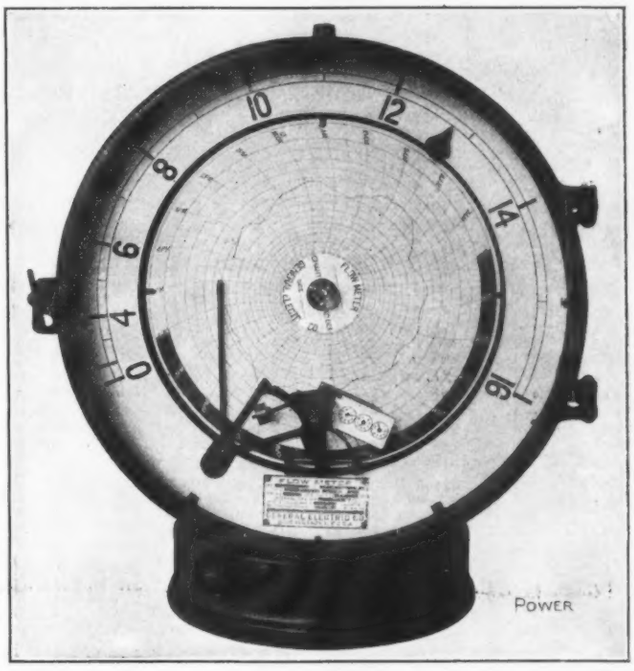


FIG. 3. METER WITH INDICATING SCALE, RECORDING CHART AND INTEGRATING DIAL

To meet the requirements of different classes of service and the various conditions met with, the meter can be made up in four different ways: First, as a recording or curve-drawing instrument; second, with both indicating scale and recording chart; third, with recording chart and integrating dials, and, fourth, with indicating scale, recording chart and integrating dials.

Wilkins Gage-Glass Cutter

The Wilkins gage-glass cutter is manufactured by George H. Wilkins, 57 West Lake St., Chicago, Ill. The cutting wheel is set in the end of the measuring rod at the zero mark. This rod is graduated accurately in eighths of an inch up to 8 in. The cutting wheel is held in place by a removable pin and an extra wheel is supplied with each cutter.

The cutting wheel can be pressed against the glass by means of the tongue, which is connected to a thumb lever through a link. An adjustable collar can be set at any point on the rod to form a rest or guide while cutting the glass.

Powerene, a new fuel, has recently been introduced by Dr. J. W. Rae and Reece Lockwood, of Bowling Green, O., says "Commercial Vehicle." It has not been definitely classified, but it is supposed to be secured as a byproduct of petroleum after gasoline has been extracted. It is said to be more effective as a fuel, giving greater power, that it does nor carbonize, and that it can be marketed for 3 cents per gallon.

Kilowatt Hours per Ton of Coal at Various Evaporations

By Charles H. Sammons

The following table shows the kilowatt-hours available from a ton (2240 lb.) of coal for different actual evaporation rates and for steam consumption per kilowatt-hour varying from 8 to 60 lb.

The table was compiled according to the following calculations:

Assume an actual evaporation of 4.5 lb. of water per lb. of coal; the steam consumption per kilowatt-hour being, say, 14 lb. Then the number of kilowatt-hours available from a ton of coal under these conditions is:

$$\frac{2240 \times 4.5}{14} = 720\ kw.\text{-}hr.$$

The table should be found useful in nearly every plant as it covers a wide range both as to evaporation and steam consumption of the generating sets.

WATER ACTUALLY EVAPORATED LB. PER LB. OF COAL

Steam Consumption per Kw.-Hr. of Engine in Lb.	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	10½	11
60	149.33	168.00	186.66	205.33	224.00	242.66	261.33	280.00	298.66	317.33	336.00	354.66	373.33	392.00	410.66
59	151.85	170.84	189.65	208.46	227.27	246.08	264.89	283.70	303.72	322.71	340.16	360.67	379.66	398.64	417.62
58	154.48	173.79	193.10	212.41	231.72	251.03	270.34	289.65	308.96	328.27	347.58	366.89	386.2	405.51	424.82
57	157.19	176.84	196.49	216.14	234.03	255.43	275.08	294.73	314.38	334.03	353.68	373.33	392.98	412.63	432.28
56	160.00	180.00	200.00	220.00	240.00	260.00	280.00	300.00	320.00	340.00	360.00	380.00	400.00	420.00	440.00
55	162.90	183.27	203.63	224.00	244.36	264.72	285.09	305.45	325.81	346.18	366.54	386.9	407.27	427.63	448.00
54	165.92	186.66	207.4	228.14	248.88	269.62	290.37	311.11	331.85	352.59	373.33	394.07	414.81	435.55	456.29
53	169.05	190.18	211.32	232.45	253.58	274.71	295.84	316.98	338.11	359.24	380.37	401.5	422.64	443.77	464.9
52	172.3	193.84	215.38	236.92	258.46	280.00	301.53	323.07	344.61	366.15	387.69	409.23	430.76	452.30	473.84
51	175.68	197.64	219.67	241.56	263.52	285.49	307.45	329.01	351.37	373.33	395.29	417.25	439.21	461.17	483.13
50	179.2	201.6	224.00	246.4	268.8	291.2	313.6	336.00	358.4	380.8	403.2	425.6	448.00	470.4	492.8
49	182.85	205.71	228.57	251.42	274.28	297.14	320.00	342.85	365.71	388.57	411.42	434.28	457.14	480.00	502.86
48	186.66	210.00	233.33	256.66	280.00	303.33	326.66	350.00	373.33	396.66	420.00	443.33	466.66	490.00	513.33
47	190.63	214.46	238.29	262.12	285.93	309.78	333.61	357.44	381.27	405.1	428.93	452.76	476.59	500.42	524.25
46	194.78	219.13	243.47	267.82	292.17	316.52	340.86	365.21	389.56	413.91	438.26	462.6	486.95	511.3	535.65
45	199.11	224.00	248.88	273.77	298.66	323.55	347.11	373.33	398.22	423.11	448.00	472.88	497.77	522.66	547.55
44	203.63	229.09	254.54	280.00	305.45	330.9	356.36	381.81	407.27	432.72	458.18	483.63	509.09	534.54	560.00
43	208.37	234.41	260.46	286.51	312.55	337.2	364.65	390.69	416.74	442.79	468.63	494.88	520.93	546.97	573.02
42	213.33	240.00	266.66	293.33	320.00	346.66	373.33	400.00	426.66	453.33	480.00	506.66	533.33	560.00	586.66
41	218.53	245.85	273.17	300.48	327.8	355.12	382.43	409.75	437.07	464.34	491.7	519.02	546.39	573.65	600.97
40	224.00	252.00	280.00	308.00	336.00	364.00	392.00	420.00	448.00	476.00	504.00	532.00	560.00	588.00	616.00
39	229.74	258.46	287.17	315.89	344.61	373.33	402.05	430.76	459.48	488.2	516.92	546.64	574.35	603.07	631.78
38	235.78	265.26	294.73	324.21	353.68	383.15	412.63	442.11	471.57	501.05	530.52	560.00	589.47	618.94	648.42
37	242.16	272.43	302.7	332.97	363.24	393.51	423.78	454.05	484.32	514.59	544.86	575.13	605.4	635.67	665.94
36	248.88	280.00	311.11	342.22	373.33	405.00	435.55	466.66	497.77	528.88	560.00	591.11	622.22	653.33	684.44
35	256.00	288.00	320.00	352.00	384.00	416.00	448.00	480.00	512.00	544.00	576.00	608.00	640.00	672.00	704.00
34	263.52	296.47	329.41	362.35	395.29	428.23	461.17	494.11	527.05	560.00	592.94	625.88	658.82	691.76	724.7
33	271.51	305.45	339.39	373.33	407.27	441.21	475.15	509.09	543.03	576.96	610.9	644.84	678.78	712.72	746.66
32	280.00	315.00	350.00	385.00	420.00	455.00	490.00	525.00	560.00	595.00	630.00	665.00	700.00	735.00	770.00
31	289.03	325.16	361.25	397.41	433.54	476.12	505.8	541.93	578.06	614.19	650.32	686.45	722.58	758.70	794.83
30	298.66	336.00	373.33	410.66	448.00	485.33	522.66	560.00	597.33	634.33	672.00	709.33	746.66	784.00	821.33
29	308.95	347.58	386.2	424.82	463.44	502.06	540.68	579.31	617.93	656.55	695.17	733.79	772.41	811.03	849.65
28	320.00	360.00	400.00	440.00	480.00	520.00	560.00	600.00	640.00	680.00	720.00	760.00	800.00	840.00	880.00
27	331.85	373.33	414.81	456.29	497.77	539.25	580.74	622.22	663.70	705.18	746.66	788.14	829.62	871.11	912.59
26	344.61	387.69	430.76	473.84	512.92	560.00	603.07	646.15	689.23	732.3	775.38	818.46	861.53	904.61	947.69
25	358.40	403.2	448.00	492.8	537.6	582.4	627.2	672.00	716.8	761.6	806.4	851.2	896.00	940.8	985.6
24	373.33	420.00	466.66	513.33	560.00	606.66	653.33	700.00	746.66	793.33	840.00	886.66	933.33	980.00	1026.66
23	389.56	433.91	486.95	535.65	584.34	633.04	681.73	730.43	779.13	827.82	876.52	920.86	973.91	1023.6	1071.3
22	407.27	458.18	509.09	560.45	610.9	661.81	708.13	763.63	814.54	865.45	916.36	967.27	1018.18	1069.09	1120.00
21	426.95	480.00	533.33	586.66	640.00	693.33	746.66	800.00	853.33	906.66	960.00	1013.33	1066.66	1120.00	1173.33
20	448.00	504.00	560.00	616.00	672.00	728.00	784.00	840.00	896.00	952.00	1008.00	1064.00	1120.00	1176.00	1232.00
19	471.58	530.52	589.47	648.42	707.36	766.31	825.26	884.21	943.15	1002.1	1061.05	1120.00	1178.94	1232.06	1296.84
18	495.78	560.00	623.33	684.44	746.66	808.88	871.11	933.33	995.55	1067.77	1120.00	1182.22	1244.44	1306.66	1363.33
17	527.05	592.94	658.82	724.7	790.58	856.47	922.35	988.23	1054.11	1120.00	1185.88	1251.76	1317.64	1383.52	1448.23
16	560.00	630.00	700.00	770.00	840.00	910.00	980.00	1050.00	1120.00	1190.00	1260.00	1330.00	1400.00	1470.00	1540.00
15	597.33	672.00	746.66	821.33	896.00	970.66	1045.00	1120.00	1194.66	1266.66	1344.00	1418.66	1493.33	1568.00	1642.66
14	640.00	720.00	800.00	880.00	960.00	1040.00	1120.00	1200.00	1280.00	1360.00	1440.00	1520.00	1600.00	1680.00	1760.00
13	689.23	775.38	861.53	947.69	1033.84	1120.00	1206.15	1292.3	1378.46	1464.61	1550.76	1636.92	1723.07	1809.23	1895.38
12	746.67	840.00	933.33	1026.66	1120.00	1213.33	1306.66	1400.00	1493.33	1586.66	1680.00	1773.33	1866.66	1960.00	2053.33
11	814.6	916.36	1018.18	1120.00	1221.81	1323.63	1425.45	1527.27	1629.09	1730.9	1832.72	1934.54	2036.36	2138.18	2240.00
10	896.00	1008.00	1120.00	1232.00	1344.00	1456.00	1568.00	1680.00	1792.00	1904.00	2016.00	2128.00	2240.00	2352.00	2464.00
9	995.57	1120.00	1244.44	1368.88	1493.33	1617.77	1742.22	1866.66	1991.11	2115.55	2240.00	2364.44	2488.88	2513.33	2737.77
8	1120.00	1260.00	1400.00	1540.00	1680.00	1820.00	1960.00	2100.00	2240.00	2380.00	2520.00	2660.00	2800.00	2940.00	3080.00

Table showing kw.-hr. per ton (2240 lb.) of coal. For different actual evaporations of water per lb. coal and various steam consumptions per kw. of engine.

The recent decision of the Supreme Court of the United States in the Chandler-Dunbar case is regarded by Senator Burton, of Ohio, as of the utmost importance because of the sweeping extent to which it upholds government ownership and control of water-power and navigable rivers, and at his request the decision is being printed as a public document. The court held that owners of the river banks or river bed have no ownership of the water-power as against the government seeking to improve a river for navigation. Senator Burton laid particular stress upon that part of the decision which says that the government need not let the water-power go to waste but may use it or lease it to private individuals or concerns. This opinion of the court is evidently a direct answer to arguments recently advanced to the effect that after improving a river or stream for navigable purposes the government could not control the water-power incidentally created but must let it revert to the owners of the abutting property.—"Electrical World."

A reservoir of 400 acres is to be constructed by means of two embankments running from an island to the mainland. The reservoir is to be further subdivided into an upper and lower tank by another embankment. The assumptions for operation are as follows: When the water in the sea is higher than in the lower reservoir or tank, it will flow in through turbines, the flow starting some time after high tide and stopping after the beginning of low tide. If the water in the sea be lower than in this tank, then through sluices it is to flow into the sea. In the upper reservoir, when the sea is higher than the tank, it will be filled through sluices, and when lower the water will flow off through turbines. A uniform tidal amplitude of 3 meters is counted upon and a difference of level of 1½ m. between the sea and the tank actually in operation. The cost of producing electricity by this means is estimated at 20 to 25 mills per kw.-hr. No necessary expense for accumulators is expected, and the cost of construction is about $1,000,000.—"Canadian Engineer."

ELECTRICAL DEPARTMENT

Primer of Electricity

By Cecil P. Poole

Wave-Connected Armature Windings

Wave-connected armature windings have two peculiarities, aside from the "throw" or spread of the coil terminals, which distinguish them from lap windings, and these are important advantages. One is that any even number of paths through a winding, up to the number of field-magnet poles, may be obtained; the other is that the conductors in each path through the winding are commonly called "short pitch" and "long pitch," because the terminals of each coil are connected to the commutator farther apart in one case than in the other. Figs. 176 and 177 illustrate these statements; both diagrams show a pair of coils of a 15-coil, two-path winding having equal spread or core pitch but different commutator pitches. In Fig. 176 the coils are connected with long pitch and in Fig. 177 with short pitch; the pitch in the former diagram is 8 and in the latter it is 7.

The short-pitch connection is preferable in all cases, because it results in fewer crossings between the leads from the winding to the commutator. As Fig. 176 shows,

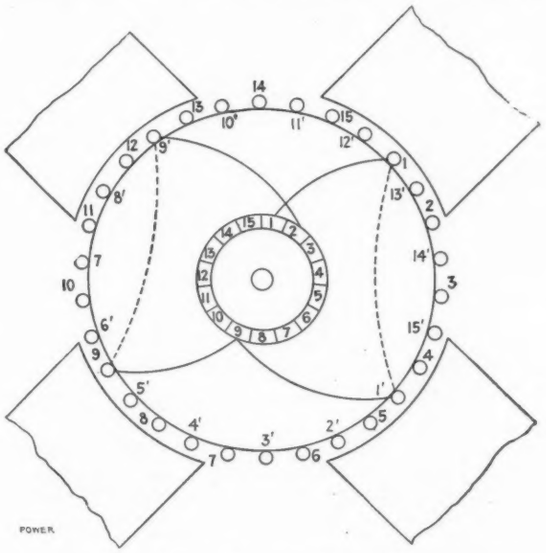


Fig. 176. Long-Pitch Wave Connection

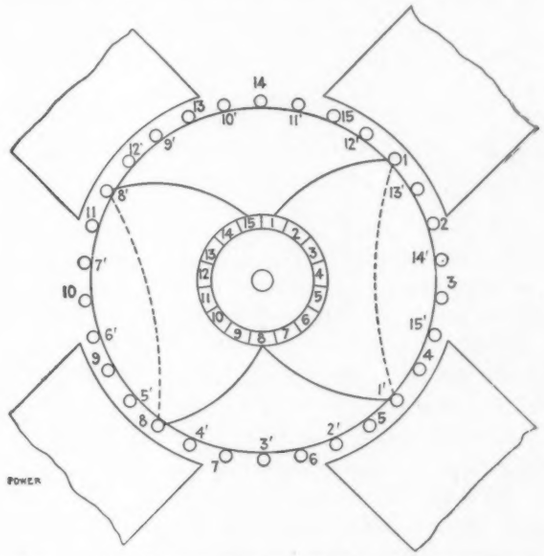


Fig. 177. Short-Pitch Wave Connection

subjected to the influence of every pole on the field magnet. (In a simple lap winding the number of paths is necessarily equal to the number of field-magnet poles and the conductors in each path are influenced by only two of the field-magnet poles at one time, no matter how many there may be.)

The number of paths through a wave winding is determined by the number of coils in the winding and the distance apart of the terminals of each coil at the commutator; the latter is called the commutator "pitch," and is reckoned in commutator bars. For example, in Fig. 177, the right-hand terminal of each coil is connected to the commutator seven bars distant from the left-hand terminal: the commutator pitch in this case, therefore, is 7.

For all machines except those having half as many armature paths as there are field-magnet poles, or an equal number of both, there is only one possible commutator pitch for a wave winding having a given number of coils and paths; for machines in which the number of paths equals the number of poles or one-half that number, there are two possible commutator pitches for each combination of coils, poles and paths. These are the right-hand terminal of the second coil in each series of two crosses the left-hand terminal of its mate when the long-pitch connection is used; coils 1 and 9 form the series pair shown here. In Fig. 177, this crossing does not occur. Coils 1 and 8 form a series pair, the short-pitch connection causing coil 1 to be connected to coil 8 instead of coil 9 as in Fig. 176, and the right-hand lead of coil 8 does not cross the lead of coil 1.

The short-pitch connection gives a left-handed progression in the winding and the commutator sequence. The progression is reckoned by neighboring coils and commutator bars, as in the case of lap-connected windings, but the path passes through two coils in series (in a four-pole machine) before reaching the neighboring coil and bar. Reference to Fig. 178 will make this clearer. Tracing from bar 1 through coil 1,1′, it is necessary to trace on through coil 8, 8′ in order to get to the adjacent bar. This bar is No. 15 and the progression is, therefore, left-handed or counter-clockwise.

In a four-pole wave winding the progression is double, because of the fact that the path from one commutator bar to its neighbor leads through two coils in series. The progressions in Fig. 178 are as follows:

Primary progression		Secondary progression
Bar 1 through Coil 1, 1′	to	Bar 8 and through Coil 8, 8′ to
Bar 15 through Coil 15, 15′	to	Bar 7 and through Coil 7, 7′ to
Bar 14 through Coil 14, 14′	to	Bar 6 and through Coil 6, 6′ to
Bar 13 through Coil 13, 13′	to	Bar 5 and through Coil 5, 5′ to
Bar 12 through Coil 12, 12′	to	Bar 4 and through Coil 4, 4′ to
Bar 11 through Coil 11, 11′	to	Bar 3 and through Coil 3, 3′ to
Bar 10 through Coil 10, 10′	to	Bar 2 and through Coil 2, 2′ to
Bar 9 through Coil 9, 9′	to	Bar 1.

Reading down the columns gives the progressions.

It will be noticed that the two paths are not equal; one passes through eight coils and the other through seven. This is objectionable because the electromotive

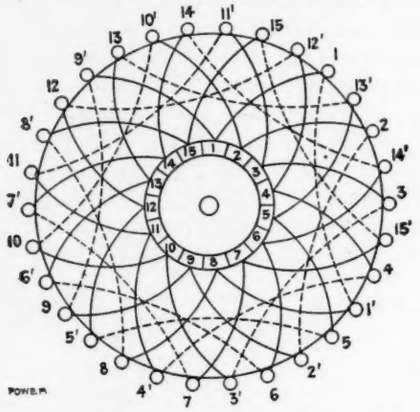


FIG. 178. FOUR-POLE TWO-PATH WINDING WITH 15 COILS

forces induced in the two paths are not quite equal, but in machines of medium and large sizes the difference is not serious because the number of coils is so large.

The general relation between the commutator pitch, number of coils, number of armature paths and number of field-magnet poles is given by the formula:

$$\frac{Poles \times pitch + or - paths}{2} = number\ of\ coils$$

This formula may be stated in rule form, thus:

1. A simple wave winding to contain a stated number of paths must contain n *coils more or less than a multiple of one-half the number of magnet poles,* n *being one-half the number of paths. (The multiplier is the commutator pitch.)*

Example: Number of poles = 8; number of coils, somewhere around 250; number of paths desired = 4. One-half the number of magnet poles is 4, and the multiples of 4 that are nearest to 250 are 248 and 252. One-half the number of paths is 2; therefore the winding may contain 2 more or less than 248 coils, or 2 more or less than 252 coils—in other words, 246, 250 or 254 coils may be used.

II. The commutator pitch of a simple wave winding is equal to twice the number of armature coils plus or minus the number of paths and divided by the number of field-magnet poles. (The division must be without a remainder.)

Example: Number of coils = 181; number of paths = 2; number of poles = 6. The commutator pitch must be either

$$\frac{2 \times 181 + 2}{6} \text{ or } \frac{2 \times 181 - 2}{6}$$

Since 2 + 181 + 2 = 363, it is not divisible by 6 without a remainder, and the pitch must be, therefore,

$$\frac{2 \times 181 - 2}{6} = 60$$

III. The number of paths in a wave winding is equal to the difference between twice the number of coils and the product of poles × commutator pitch.

Example: Number of coils = 182; number of poles = 6; commutator pitch = 60. The number of paths through the winding is

$$(2 \times 182) - (6 \times 60) = 4$$

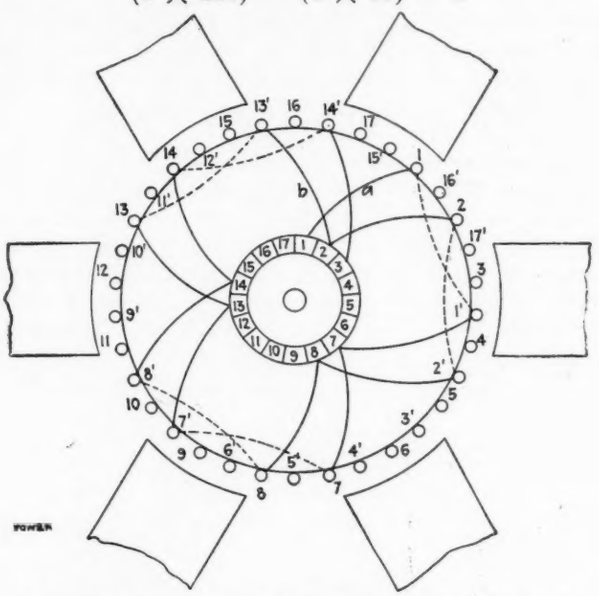


FIG. 179. MAXIMUM CROSSING, DUE TO USING THE SMALLER AVAILABLE NUMBER OF COILS

IV. A wave winding containing a number of coils exactly divisible by one-half the number of field-magnet poles will contain as many paths as there are magnet poles.

Example: A four-pole machine has 30 armature coils and the commutator pitch is 14. According to Rule III the number of paths is

$$(2 \times 30) - (4 \times 14) = 4$$

Almost all wave-connected windings used in this country are of the two-path kind and are put chiefly on machines of small and medium sizes. As the average reader

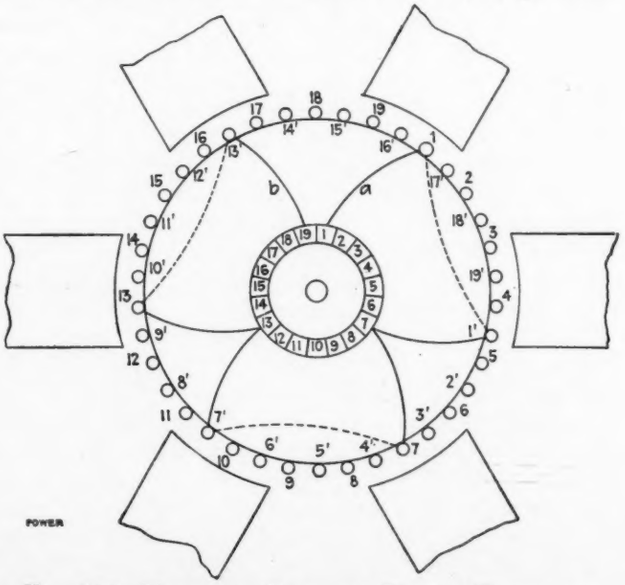


FIG. 180. MINIMUM CROSSING, DUE TO USING THE LARGER AVAILABLE NUMBER OF COILS

of this series will have to deal largely with machines of this class it may be useful to have Rules I and II modified to apply to such machines; thus:

I-a. A two-path wave winding must contain one coil more or less than an exact multiple of one-half the number of field-magnet poles.

II-a. The commutator pitch of a two-path wave winding is equal to twice the number of coils plus or minus 2, divided by the number of field-magnet poles.

Consideration of Rules I and I-a will show that there are two numbers of coils that can be used for each combination of other features. For example, a six-pole machine could have a two-path winding with either 149 or 151 coils, with a commutator pitch of 50; or a winding of either 161 or 163 coils with a commutator pitch of 54, and so on. This is due to the "plus or minus" feature of the ruie—"one coil more or less" than a certain number, which number is the product of poles × commutator pitch. It is better to use the larger of the two values, because there are fewer crossings of armature leads and the neighboring leads of each set of series coils do not cross each other.

This principle is illustrated by Figs. 179 and 180. The former is a 17-coil winding and the latter a 19-coil winding for a six-pole machine, the pitch being six in both cases. The 17-coil winding contains one coil *less* and the 19-coil winding one coil *more* than an exact multiple (18) of one-half the number of magnet poles In the former, the starting lead *a* of coil 1 is crossed by the lead *b* of coil 13; the three coils 1, 7 and 13 forming a series set. In Fig. 180, where the coils 1, 7 and 13 also form a series set, the leads of coils 1 and 13 do not cross one another.

CORRESPONDENCE

Novel Transformer Connections

A short time ago it became necessary to increase the capacity of one of our stations which distributed by a three-phase, 2300-volt system. The only machine immediately available was a 100-kw., 1100-volt, two-phase, belt-driven alternator. By the use of three stock transformers, connected as shown in Fig. 1, however, we were enabled to parallel this machine with the other generators. This was accomplished as follows:

The alternator had two separate windings brought out to four taps, the two outside ones of which were connected together, forming a two-phase, three-wire system. The transformers *M* and *N* were of 50 kv.-a. each and had two primary coils to adapt them to either 1100 or 2200 volts. The primary coils were connected in series as for 2200 volts and the center taps were brought out through the case.

Connections were made to the generator, see Fig. 1, so that the right half of transformer *M* got 1100 volts between A_1 and A_2 and the left half of transformer *N*, 1100 volts between B_1 and B_2. This set up an auto-transformer effect, inducing 1100 volts across the left half of *M* and the right half of *N*; that is, the total voltage across the outside terminals of both transformers *M* and *N* was 2200 volts.

Considering only the terminals *CD* and *EF* of the transformer, this made practically a two-phase, 2200-volt circuit. The connection from *E* to the middle point of transformer *M* converted this to a three-phase system, with phases across *CF*, *DF* and *CD*. This, however, gave a poor balance, so one-half of the secondary coil of *M* was connected in circuit as shown, both transformers being 440-220 volts on the secondary side. In addition, a

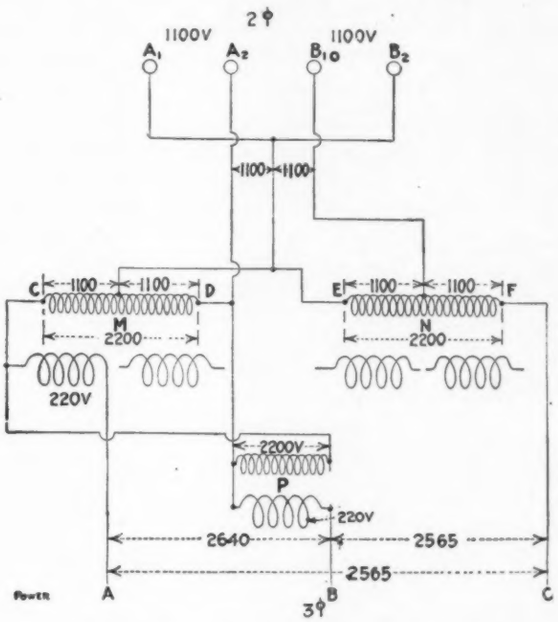


FIG. 1. TRANSFORMER CONNECTIONS

5-kv.-a. transformer *P* was placed across *CD* and the secondary was connected in series with *B*.

The voltage between *B* and *C*, also *A* and *C* is

$$\sqrt{2200^2 + (1100 + 220)^2} = 2565$$

as represented in the vector diagram, Fig. 2.

The voltage across *A* and *B* is

$$2200 + 220 + 220 = 2640$$

as is also shown in the diagram.

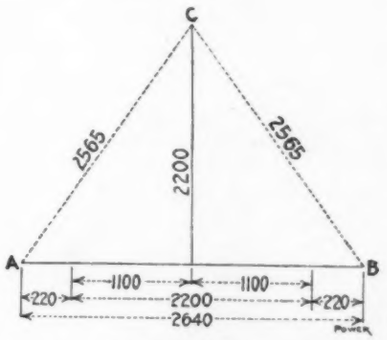


FIG. 2. GRAPHIC REPRESENTATION OF VOLTAGES

By cutting down the generator voltage by means of the field rheostat from 1100 to 1000 volts, the voltage across *AB* was reduced to 2400 and across both *AC* and *BC* to 2330. The remainder of the secondary coils were taped and were not used.

EARL R. FILKINS.

Dixon, Ill.

GAS POWER DEPARTMENT

Make-and-Break Igniters

By Earl Pagett

The make-and-break ignition system is usually considered the simplest method of gas-engine ignition. There are, however, many puzzling peculiarities found in connection with its operation, especially to the novice.

A few of these will be taken up and explained briefly, although it is first necessary to understand the operation of the igniter. This system consists essentially of (1) a source of electric current; (2) a pair of electrodes, one movable and one stationary; (3) a body-piece in which to mount the electrodes; and (4) a tripping and timing mechanism.

Operation of Igniter

The source of current is usually either a number of dry cells, a magneto, a storage battery or a combination of magneto and battery. From three to five amperes at

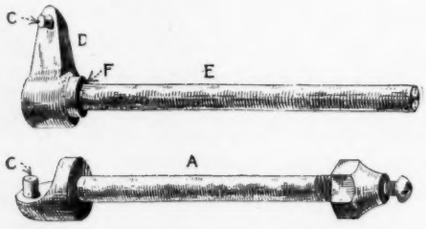


Fig. 1. Stationary and Movable Igniter

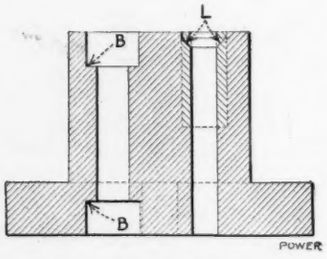


Fig. 2. Body Piece

six or eight volts is sufficient. Any more than this only burns the points needlessly. Fig. 1 represents a pair of electrodes in which *A* is the stationary and *E* the movable members. They project into the cylinder and the points *CC* are brought together and separated quickly by the tripping mechanism at the proper instant, causing ignition of the gas by the resultant arc.

The stationary electrode is insulated from the body-piece with mica, or some other heat-resisting nonconductor. The positive wire is usually connected to this electrode and the negative wire is grounded to the engine frame, but not necessarily, as either way will do.

The movable electrode consists of an arm *D* and a stem *E*, Fig. 1. The arm *D* carries the point *C*, and the stem passes through the body and the actuating mechanism is attached to the outer end. A shoulder *F* seats against the body-piece and right here is where trouble often occurs as will be explained later.

The body-piece is made the most convenient shape to receive the electrodes and hold the tripping and turning mechanism. The hole through which the stem of the movable electrode passes is made of such size as to make a running fit with the stem. The hole for the insulated electrode is made somewhat larger than the electrode stem and is counterbored at each end to receive the insulating washers, as shown at *BB*, Fig. 2.

Fig. 3 shows the tripping and timing mechanism of one form of this class of igniter. Nearly all others of this class work similarly. The arm *A*, Fig. 3, is fastened rigidly to the end of the movable electrode stem with the half-round taper pin at *B*. The arm *C* does not fasten to the movable stem, but has an opening which fits over the stem behind *A*. The edge of *C* is bent over arm *A* on top and also under it, and rests on the pin *H* at the bottom, leaving a lip at *E* to be engaged by the finger *F*. A spring *D* fits on a pin in the lower part of *C* and into a hole in *A*; another spring *D* also fits over a pin in the

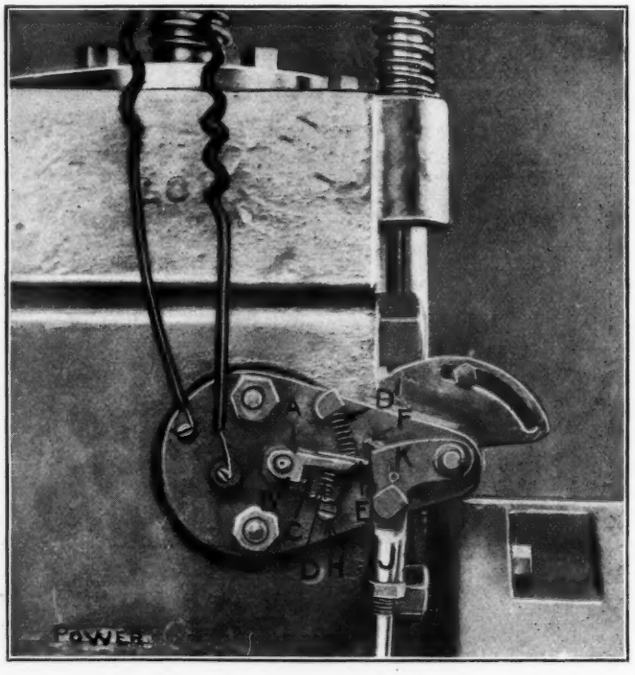


Fig. 3. Ignition System Outside the Cylinder

upper part of *C* and into a hole in a pin, which is screwed into the body of the igniter. The operation is as follows: The rod *J* is given an oscillating motion from an eccentric on the camshaft, and the finger engages the lip *E*, raising both the arms *A* and *C* until the points are brought together in the cylinder or valve chamber, after which there is no further upward movement of *A*. The arm *C* continues upward, however, compressing both

springs *D* and *D'*, until the instant of ignition, when the finger slips off the lip *E* and allows the springs to force *C* onto *A*, thereby opening the circuit quickly and causing the arc between the points on the inside of the cylinder. A spring inside at *K* allows the finger to push back and pass *E* on the return stroke, after which the cycle is repeated.

Igniter Troubles

The troubles with this class of igniter may be either mechanical or electrical. The most common is the sticking of the movable electrode in the body of the igniter. To the novice this may appear to be due to insufficient lubrication, but it is usually caused by the stem being covered with carbon. This is because the shoulder does not fit tightly against its seat, and allows the burning gases to leak past the shoulder and burn the oil on the stem, causing it to stick If this shoulder is ground to a tight fit with oil and emery the chances are that no more trouble will be experienced in this line. The shoulder can be ground by fastening the igniter in a vise and turning the stem with a breast drill or, better still, chuck the end of the stem in a lathe or drill press, hold the body and let the machine turn the stem.

The insulated electrode will have to be removed, so that the stem can turn all the way around. It is best not to try to change stems at all. When the point becomes too short on this electrode, take it out and put in a new point. If it is inconvenient to have the engine out of commission long enough, it will pay to have an extra igniter on hand.

In order to prepare the body for a new electrode it is necessary to drill out and bush the hole square to fit the new shoulder. In drilling out the hole for the bushing, a drill of about the same diameter as the outer diameter of the shoulder should be used. One inch is deep enough to drill. After the hole is drilled a brass or cast-iron plug is turned to a snug driving fit, driven in and cut off flush with the body. The hole is then drilled through this plug from the opposite end with a drill of the same size as the original hole. This makes a neat job, as shown by the dotted lines in *L*, Fig. 2. The new electrode can now be ground to this and the igniter is as good as new.

Another source of trouble is in the contact points. Some builders use points of such small diameter that they soon burn off so short that the tripping mechanism cannot bring them together properly. This necessitates taking out the old points and putting in new ones. While some builders use platinum for these points, cold-rolled steel will answer well, excepting that it will not last quite as long. It has been the writer's practice in pointing the movable electrode to turn ⅜-in. round cold-rolled steel down on one end to fit the hole in the electrode, drive it through to the shoulder and head it over on the other side. For the stationary electrode, a piece of the same kind of material ¾ in. diameter by ¾ in. long is drilled and tapped axially and the stem is screwed into it. All that is required to renew the points then is to loosen the nut on the outer end and turn this electrode so that the point on the movable electrode finds a new contact on the ¾-in. disk.

The same material should be used for the disk that is used for the point because if contacts of dissimilar metals are used, a deposit from one seems to form on the other and this will cause poor contact and a weak spark will result.

Another trouble that sometimes arises and is hard to locate is caused by a point working loose in its socket. It may be hardly loose enough to detect, but the joint tends to soot over and poor contact results. The points must be kept tight.

Providing the source of current is not to be questioned, the electrical faults may be either grounding of the insulated side or poor contact. The following simple test will usually identify the trouble. With the igniter tripped and with current turned on, disconnect the wire from the insulated electrode. Touch it firmly to the body of the igniter or any convenient part of the engine frame and let it spring off quickly. If a good spark results the source of current and the conductors to the igniter are all right.

Next touch the wire to the insulated electrode. If a spark occurs here this electrode is grounded. If none occurs it is as it should be. Now push up the tripping mechanism until the points are together and repeat the operation on the insulated electrode. If a good spark occurs the points are clear but if no spark or a very weak one occurs, the trouble is in the points.

Lubricating troubles are seldom experienced with the igniter stems on four-stroke-cycle engines. Some trouble is experienced at times, however, with the igniters on two-stroke-cycle engines. This can be traced to the fact that there is a sort of endwise check-valve action to the stem on the four-stroke-cycle machine that is absent on the two-stroke-cycle engine. That is, the shoulder is pushed against its seat during the compression, explosion and exhaust strokes and is pulled away during the suction stroke of the four-stroke-cycle engine, while the shoulder is held against the seat at all times in the two-stroke-cycle engine. In the latter case it is difficult to get oil to the shoulder and the inner end of the stem without flooding which usually causes trouble through the formation of carbon.

The writer has had favorable results by oiling the stems only when they are taken out and cleaned after a run of 168 to 240 hr. and using then only an amount that could be rubbed on with the finger. Some of the late engines have the igniters water-jacketed, which practice tends to keep down carbon trouble.

⁂

Anyone who works with gas engines, coke ovens or gasoline apparatus that requires vapors rich in hydrogen, has been at one time or another confronted with preignition difficulties. To these the method of Dugald Clerk comes as a most timely help. His procedure is to substitute for the air in the gaseous charge, some of the cooled exhaust products. Thus the inert gas which is added reduces all chance of inflammability by greatly diminishing the oxygen yet without diminishing to any appreciable degree the total power of the charge.

Another discovery of Dr. Clerk while on the Gaseous Explosion Committee of the British Association, was that the greater part of the heat was lost during the expansion stroke which occurs at the crest of the temperature wave. This he proved to be not a surface loss, but a loss by radiation.

⁂

According to the United States Geological Survey, the quantity of coal used for coke making in the United States in 1912 was 65,485,801 short tons. The coke produced from this coal amounted to 43,916,834 short tons, valued at $111,523,336, besides large quantities of gas, tar, benzol, ammonia, etc., as byproducts from the 11,048,489 tons of coke produced in byproduct ovens.

REFRIGERATION DEPARTMENT

Capacity of Ammonia Compressors

By R. L. Mossman

The accompanying sketches show some diagrams taken from ammonia compressors. Fig. 1 is a diagram taken from a double-acting, wet-compression machine with weak suction-valve springs. As will be seen, there is no projection below the suction line, the weak springs causing the valves to leak slightly. The cylinder diameter is 19 in.; the stroke, 36 in.; the speed, 40 r.p.m.; head pressure, 190 lb.; back pressure, 17 lb., and the spring 100.

Fig. 2 shows the result of running a compressor at too high piston speed for the size of the suction valves. The machine was running at 120 r.p.m., single acting, against a head pressure of 153 lb., and suction of 20 lb. gage.

The apparent tonnage of the machine, while running at 120 r.p.m., is figured as follows: Area of cylinder, 78.54 sq.in.; capacity in cubic inches, 78.54 × 18 =

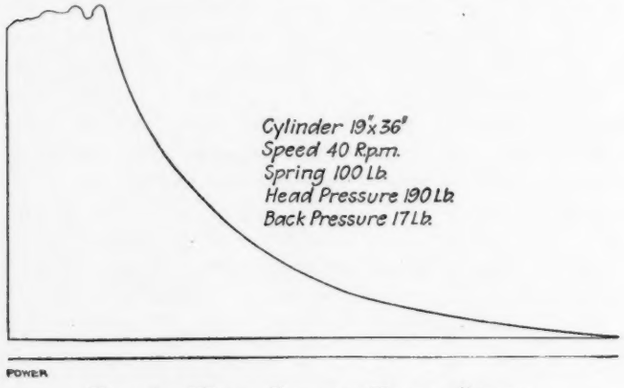


Fig. 1. Weak Suction-Valve Spring

1413.72 cu.in.; cubic feet displacement per minute at 100 per cent. efficiency,

$$\frac{1413.72 \times 120}{1728} = 98 \textit{ cu.ft.}$$

As the diagram shows a reëxpansion loss of 8 per cent., the amount of gas that can enter the cylinder is 92 per cent. of its volume.

The loss due to the low suction pressure in the cylinder, caused by the high speed, is as follows: The suction pressure shown by the gage is 20 lb. or 34.7 lb. abs. The pressure in the cylinder, as shown by the diagram, is 23.7 lb. abs. Therefore,

$$23.7 \div 34.7 = 68.3 \textit{ per cent.}$$

This means that due to the drop in suction pressure, each cubic foot of gas in the compressor represents only 68.3 per cent. of ammonia by weight that there would have been had the gage suction pressure been realized in the cylinder. The apparent efficiency is

$$0.92 \times 0.683 \times 100 = 62.8 \textit{ per cent.}$$

The actual displacement then equals

$$98 \times 0.628 = 61.54 \textit{ cu.ft. per min.}$$

The cubic feet of gas required per minute, as shown in Table 1, at 153 lb. head pressure and 20 lb. suction pressure, is 3.34 and

$$\frac{61.54}{3.34} = 18.4 \textit{ tons}$$

Using Table 2, which gives the refrigerating effect of 1 cu.ft. of gas in B.t.u. at different pressures, the tonnage is

$$\frac{59 \times 61.5}{200} = 18.14$$

When card *B* was taken the machine had been slowed down to 85 r.p.m. The head pressure was 153 lb., the suction pressure 25 lb. gage, or 39.7 lb. abs., and the suction pressure by card 20 lb. gage, or 34.7 lb. abs. The cylinder displacement per minute at 100 per cent. efficiency is

$$\frac{1413.72 \times 85}{1728} = 69.5 \textit{ cu.ft.}$$

Deducting the loss of 5 per cent., due to reëxpansion, leaves 95 per cent. of the cylinder volume. The suction pressure by card being 34.7 lb. abs. and by gage 39.7 lb. abs. reduces the density of the vapor to 87.4 per cent.,

TABLE 1. CU.FT. GAS REQUIRED PER MIN. TO PRODUCE 1 TON REFRIGERATION IN 24 HR. AT DIFFERENT PRESSURES

Temp. of Gas, Deg. F.	Suction Press. Gage	Temp. of Gas, Deg. F. 65	70	75	80	85	90	95	100	105
		Gage Press. 103	115	127	139	153	168	184	200	218
— 27	1	7.22	7.3	7.37	7.46	7.54	7.62	7.7	7.79	7.88
— 20	4	5.84	5.9	5.96	6.03	6.09	6.16	6.23	6.3	6.43
— 15	6	5.35	5.4	5.46	5.52	5.58	5.64	5.7	5.77	5.83
— 10	9	4.66	4.73	4.76	4.81	4.86	4.91	4.97	5.05	5.08
— 5	13	4.09	4.12	4.17	4.21	4.25	4.3	4.35	4.4	4.44
0	16	3.59	3.63	3.66	3.7	3.74	3.78	3.83	3.87	3.91
5	20	3.20	3.24	3.27	3.3	3.34	3.38	3.41	3.45	3.49
10	24	2.87	2.9	2.93	2.96	2.99	3.02	3.06	3.09	3.12
15	28	2.59	2.61	2.65	2.68	2.71	2.73	2.76	2.8	2.82
20	33	2.31	2.34	2.36	2.38	2.41	2.44	2.46	2.49	2.51

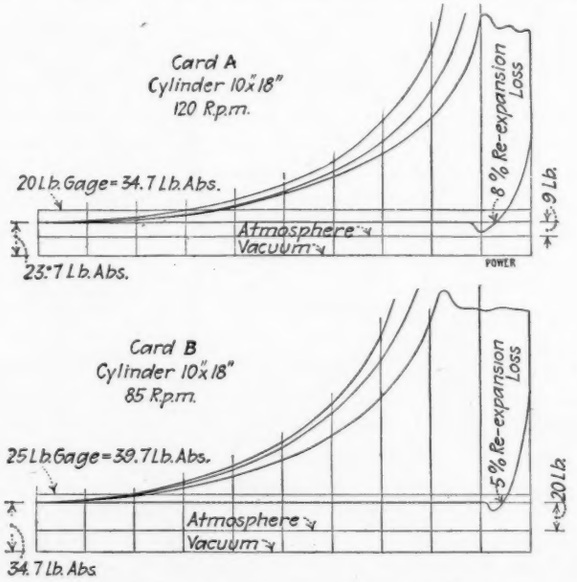


Fig. 2. Result of High Speed for Size of Suction Valve

due to the difference in suction pressures. The apparent efficiency is then

$$0.95 \times 0.874 \times 100 = 83 \textit{ per cent.}$$

The actual displacement is

$$83 \times 69.5 = 57.7 \textit{ cu.ft.}$$

According to Table 1 this would give

$$\frac{57.7}{2.92} = 19.76 \textit{ tons}$$

To be able to compare the two figures of apparent tonnage obtained from cards *A* and *B* of Fig. 2 it is necessary to equalize the suction pressures. The compressor working at 120 r.p.m. and 25 lb. instead of 20 lb. back pressure would probably show an apparent tonnage of

$$\frac{18.4 \times 3.34}{2.97} = 20.7 \textit{ tons}$$

TABLE 2. REFRIGERATING EFFECT OF ONE CU.FT. OF AMMONIA GAS AT DIFFERENT PRESSURES

Temp. of Gas, Deg. F.	Suction Press., Gage	Temp. of Liquid in Deg. F. 65	70	75	80	85	90	95	100	105
		Condenser Press. Gage 103	115	127	139	153	168	184	200	218
—27	1	27.3	27.01	26.73	26.44	26.16	25.87	25.59	25.30	25.02
—20	4	33.74	33.40	33.04	32.70	32.34	31.99	31.64	31.30	30.94
—15	6	36.36	36.48	36.10	35.72	35.34	34.96	34.58	34.20	33.82
—10	9	42.28	41.84	41.41	40.97	40.54	40.10	39.67	39.23	38.8
—5	13	48.31	47.81	47.32	46.82	46.33	45.83	45.34	44.84	44.35
0	16	54.88	54.32	53.76	53.20	52.64	52.08	51.52	50.96	50.4
5	20	61.50	60.87	60.25	59.62	59.00	58.37	57.75	57.12	56.5
10	24	68.66	67.97	67.27	66.58	65.88	65.19	64.49	63.80	63.1
15	28	75.88	75.12	74.35	73.59	72.82	72.06	71.29	70.53	69.76
20	33	85.15	84.30	83.44	82.59	81.73	80.88	80.02	79.17	78.31
25	39	95.50	94.54	93.59	92.63	91.68	90.72	89.97	88.81	87.86

The increase in speed of the machine from 85 to 120 r.p.m. increased the apparent tonnage only from 19.76 to 20.7, or 0.94 ton. In these calculations the effect of superheating in the compressor has not been taken into consideration, and this factor, depending somewhat on the design and operation of the machine, would reduce the actual refrigerating effect to from 85 to 90 per cent. of the apparent values obtained.

It is well when speeding up a compressor to apply the indicator and see that the suction pressure in the cylinder is not reduced too much below that shown by the gage.

⁂

Figuring Power for Refrigerating Plants

By Samuel Sydney

Before reasonably accurate simple computations regarding the power required for any given ice-making or refrigerating duty can be made it is essential that a correct basis for determining the amount of heat removal and a fixed unit of refrigerating capacity be known. Concerning the heat removal not only must the sensible and latent heat to be removed from the material involved be known, but also the various amounts of heat leakage.

If it is known that the goods placed in a room for cooling or the liquid placed in a can for freezing are at a certain temperature and must be reduced to another temperature, it is essential to have a correct basic rating: first for the sensible heat of the material; second for the latent heat, if its state is changed by the cooling, as in freezing water, and third for the quantity of heat that will flow from other near-by bodies to the article being cooled or frozen.

To measure sensible heat there are various temperature-measuring instruments, sufficiently accurate for nearly all purposes, so that this factor may be passed over. All substances also absorb heat at constant temperature when they change their state from solid to liquid or from liquid to gas, and this amount of heat is again made latent when they change back to their original state. To forget to allow for this latent heat might prove a costly error. Just what is the correct latent heat of the most common and most frequently used substance, water, has not yet been fully determined. When water changes its state from liquid to vapor it is known that about 970 B.t.u. for each pound must be added from and at the temperature of 212 deg. F. before the sensible heat will increase and that when recondensed to water, this vapor will surrender the 970 B.t.u. before its sensible heat falls below 212 deg. F. If frozen water, or ice, is heated its temperature rises readily to 32 deg. F., but it rises no higher on the thermometric scale until about 142 B.t.u. according to some, and 144 B.t.u. according to others, have been added per pound.

While a difference of two heat units per pound would not figure up very much on a small machine, it would amount to considerable in figuring on such a machine as the 1000-ton compressor installed by the Quincy Market Cold Storage & Warehouse Co., Boston, Mass., in 1912, or the still larger machine, said to be of 1200 tons daily refrigerating capacity, now being built in Germany for an ice-manufacturing concern in Buenos Aires, Argentine Republic. Either of these machines would be capable of producing at least 500 tons of ice daily or 1,000,000 lb. A difference of two units per pound, therefore, would mean 2,000,000 B.t.u., which is equivalent to nearly eight tons of refrigerating capacity per day.

Far greater and much more uncertain of calculation is the extra heat that must be removed because of heat leakage. If the exact coefficients of heat leakage for the various types and kinds of wall construction were known, there would be little difficulty. As it is we are confronted with a mass of estimates and with results of tests made by interested parties on particular kinds of construction differing in many ways from any that are met with in practical business.

It is learned from private and semiofficial tests that for some of the best known types of insulated-wall construction the coefficient is somewhere between 1 and 3 B.t.u. per sq.ft. of surface per 24 hr. per degree difference between outside and inside temperature. And even with this factor it is necessary to rely more or less upon estimate, as the difference between temperatures outside and inside is constantly varying as weather conditions change. With thick walls composed of material that offers comparatively little resistance to the passage of heat or of such faulty construction with the best material that conductors of heat remain in the walls, the coefficient of heat transmission rises to 5 and 6 or even to 10 and 12 units per sq.ft. per 24 hr. per degree difference. What this means is evident from a simple example. Given a room 30 ft. wide, 80 ft. long and 10 ft. high, there would be 7000 sq.ft. of surface. At 2 B.t.u. per sq.ft. per 24 hr. with a temperature difference of 30 deg., this would mean a heat gain of

$$7000 \times 2 \times 30 = 420{,}000 \textit{ B.t.u.}$$

At 10 B.t.u. heat transmission the gain would be

$$7000 \times 10 \times 30 = 2{,}100{,}000 \textit{ B.t.u.}$$

The one would mean about 1.4 tons daily refrigerating effect and the other 7.3 tons, merely for taking up heat

leakage. Then in addition the heat introduced at openings that are not air-tight when closed and that which rushes in at times of entrance and departure from the cold room, the heat radiating from the person who brings in or takes out goods, or inspects the place, and the heat radiating from lights. All these must also be considered and provided for. It is customary to make an arbitrary allowance to cover all these heat leakages. If the allowance proves too small, occasional losses on goods prove costly, as many have experienced. If the allowance is too large, there is not only the loss on extra investment but on operation of the larger plant.

In the manufacture of ice it is necessary to take up not only the latent heat per pound of water to be frozen, but also the sensible heat to be removed from the water above, and from the ice below, 32 deg. F., the heat that leaks into the can through the imperfect covers and that which leaks into the freezing tank through its insulation and from the tank surface.

Granted that the total amount of heat to be removed by refrigerating machinery for any given service has been determined closely, uncertainty again creeps in when it is desired to determine definitely just how large a machine will produce the refrigeration required.

Competent operation also enters into the question. It is not an uncommon occurrence to find refrigerating plants operated apparently at the limit of their capacity, but when taken in charge by a competent engineer who makes a few slight and inexpensive changes that the machine does from 10 to 25 per cent. more work and with actually less cost for power.

To figure the power required for an ammonia compressor it is necessary to know the temperature of the condenser water and also the quantity of water that can be used on such a condenser per minute. The type of condenser has some bearing on the case. It is necessary to know the temperature to be maintained in the refrigerator and the weight of gas that must be compressed to produce such a temperature. It is common practice to merely estimate the power required and provide accordingly. Manifestly this is not the most efficient or economical method. The rules for figuring power requirement are for the most part approximate only, as a number of factors, not usually considered, enter in to modify the result. Thus, for example, in the matter of condenser water, if one gallon per minute per ton of refrigeration per 24 hr. of 56-deg. water is used in the condenser, the resulting condenser pressure is about 150 lb. If three-fourths of a gallon of 56-deg. water is used the pressure will run up to about 190 lb. If three gallons of such water can be utilized the pressure will be only 105 lb. and the work of the compressor will be reduced between 20 and 25 per cent.

Dr. Siebel's rule for figuring the power for a compressor has probably been used more than any other and may be stated as follows:

$$P = \frac{\textit{Diff. between temp. in refr. coils and in condenser}}{\textit{Temp. in refrigerator} + 460\ (\textit{abs. temp.})} \times \textit{lat. heat of vaporization} \times \textit{weight of gas entering comp. per min.} \times 0.0234$$

The coefficient 0.0234 is obtained by dividing 778, the foot-pounds equivalent to one heat unit, by 33,000.

The weight of ammonia to be pumped per minute is found by subtracting the difference between temperatures in the condenser and refrigerator from the latent heat of vaporization at the refrigerator pressure, which gives the refrigerating effect of one pound of the refrigerant. Then the quotient obtained by dividing the total refrigerating duty expressed in thermal units by the refrigerating effect of one pound of refrigerant gives the theoretical weight of gas that must be pumped per minute.

Thus, given a case where a million British thermal units per hour are to be taken up; temperature to be maintained in chill room 20 deg. F., equal to between 10 and 15 deg. in the refrigerator coils, and liquid ammonia leaving condenser at 90 deg. From the latest ammonia tables the latent heat of vaporization at 20 deg. F. is 556; then $556 - (90 - 10) = 476$

$$\frac{1{,}000{,}000}{476 \times 60} = 35$$

the number of pounds of ammonia that must be circulated per minute to take up one million heat units per hour. Then, according to the formula,

$$P = \frac{90 - 10}{10 + 460} \times 556 \times 35 \times 0.0234 = 77.5$$

the horsepower required to operate the compressor. This does not allow for losses by friction or by superheat of the ammonia entering the compressor and hence it is customary to add from 10 to 20 per cent., or, say, an average of 15 per cent., to make up for these losses. The actual horsepower required would then be

$$77.5 + (0.15 \times 77.5) = 89.1$$

The engine driving the compressor will require about one-third more power or $89.1 \times 1\frac{1}{3} = 118.8$ *hp.*

The horsepower required for steam pumps, vacuum pumps, etc., may be figured according to formulas given in standard handbooks, but the result will be by no means always dependable, for a number of errors may creep in, due to leaks, slipping of belts, friction, imperfect valve action, etc. It is still true today, as it was ten years ago, that many pumps in actual use yield little over 50 per cent. of their theoretical capacity. The old rule of 120 lb. of steam per i.hp.-hr. for ordinary steam pumps is still not far from the amount actually consumed.

Conditions vary so greatly not only in different plants, but at different times, in the same plant, that it is exceedingly difficult to secure a short cut for figuring power requirement that would fit all cases. Temperatures of the liquid refrigerant, air or foul gases in the system, quantity of refrigerant in circulation, varying temperatures to be maintained at the same back pressure, these and other items, all effect the result.

So far as the capacity of the refrigerating machine itself is concerned, this is almost entirely proportional to the weight (not volume) of ammonia circulated and this weight depends upon the suction pressure and the cubic feet displacement of the compressor. In elaborate tests made some years ago the conclusion was reached by Professor Denton that the practical range of economical suction pressure lies between 7 lb. gage with which a temperature of zero can be maintained, and 28 lb. gage, with which temperatures above 28 deg. F. are maintained. But at 7 lb. suction pressure only about half as much ammonia by weight can be circulated as at 28 lb. back pressure. For each cubic foot of compressor displacement about one-sixth of a ton of refrigerating effect per 24 hr. can be produced at the low back pressure and about one-third of a ton at the higher back pressure.

EDITORIALS

Keokuk Hydro-Electric Power Plant

The hydro-electric station of the Mississippi River Power Co., described in this issue, will be formally dedicated on Aug. 26. Of so great public importance is this plant that President Wilson will attend the ceremonies. As will also the governors of the twenty-seven Mississippi Valley states and the entire legislatures of the three most nearly concerned states of Iowa, Illinois and Missouri.

Restrictions of space prevent proportionate treatment of the features of this gigantic development, but such as is given must be read carefully if the reader hopes to get even a glimmering conception of the magnitude of the work. While it is but slightly more difficult to write the figures representing thousands and millions than to write those representing tens and hundreds, it is well nigh impossible for ordinary mortals to appreciate the relative size or value of the quantities expressed by the former.

With over 200,000 kw. becoming available at low cost in the heart of a heretofore purely agricultural section and with good competitive transportation, facilitating the shipment of products to the big centers of distribution, the towns within one hundred or more miles of Keokuk seem destined to reap marked benefit from the erection of this plant, especially as the published policy of the power company is to reserve a large percentage of its output for sale to manufacturing enterprises. With the advent of manufacturing must come increase in population which will tend to stimulate agriculture in contiguous sections and increase both rural and urban real-estate values.

The history of the project of compelling the mightiest of the rivers in North America to do service for man extends back to 1857. In all the time since then people have constantly schemed and worked for the end that has now been attained, their efforts growing stronger and stronger as time advanced.

Ultimately, prominent men of Keokuk, Iowa, and Hamilton, Ill., organized the Keokuk & Hamilton Water Power Co., with a paid-in capital of only $2500 and having for its object the work of interesting investors, engaging engineering talent and securing the proper authority from the federal government to build the dam.

Through the activities of this company, Hugh L. Cooper, a distinguished engineer and the builder of numerous important hydraulic-power plants in this country and elsewhere, became interested and engaged in the work of securing the needed capital of twenty-odd millions, an almost Herculean task in itself, as was soon discovered. After about four years of search, during which many well nigh insurmountable difficulties were overcome, the needed funds were secured and the work of construction was started in earnest late in 1909, with Mr. Cooper personally in charge of the entire operation as chief engineer.

All of the many and unusual problems that arose during the design and construction of this unusual plant were faced and solved either by Mr. Cooper personally or by his assistants with his guidance and inspiration. Thus, the story of the realization of what had been a dream for almost three-score years, is the story of the efforts of one man.

Mr. Cooper, who is still in his forties, was born in Wisconsin and began his career as a worker on strain sheets for a bridge company. Later he built some bridges in the vicinity of Seattle, Wash. His first water-power work was done in Jamaica. Later, he built some plants in Mexico and Brazil. Then he constructed the plant at Niagara Falls, the tailrace of which is a tunnel opening under the curtain of the falls. His next plant was at McCall's Ferry, Penn., and before this was completed he began his labors on the Keokuk development.

⁂

Treatment of Employees

A system of medical inspection has been instituted by the Brooklyn Rapid Transit Co., which has much to commend it.

It seems that this company interested itself in the welfare work of its employees to the extent that it investigated the treatment of excuses offered for illness and absence by the employees in the various divisions and found that many men reported sick to get time for recreation purposes.

To meet this condition a medical-inspection bureau was established and the results of six months' working show a reduction of twenty-three per cent. in the number of days lost on account of illness as compared with the first six months in 1912.

The pleasing part of the results is that the reduction in time lost due to illness is not due to a decrease in the number of men reporting sick, but to a shortening of the time of sickness. Prior to the establishment of the system many men would contract minor illnesses and continue to work until the sickness had developed into something serious, which forced them to be absent for a week or more.

Now the men go for examination as soon as they feel slightly sick and much time and money is saved both to the individual and the company. The work is carried on by the same organization which conducts the free medical attendance in connection with the mutual-benefit association among the employees of the company.

The whole thing—system and results—illustrates the value of treating employees as men and citizens and not as mere machines or commodities. If a system of this kind should be organized in any concern, and the actions of those at the head of the system should give the employees the suspicion that there were other than mutual welfare motives back of it all, the system would do more harm than it could ever undo. Most men will respond with kindness and good will to kindly treatment and will as quickly retailiate if approached with trickery that they think aims to do them no good.

The boss of former times, who cursed like a pirate and

who thought the most effective way to get results was to make his men afraid of him, is gone. A work room, power plant or business office will not get out good work if conducted like a Sunday school, and less real work will be done if run like a whaling crew. Treat employees with kindness and discharge those shirks and fakers that will not respond. The medical-inspection system of the Brooklyn Rapid Transit Co. is a commendable step in this, the right direction.

Selecting Engineers

"The largest sums of money, the finest materials, the latest and best equipment, the most cleverly and intelligently devised methods will not be efficient unless there are men fitted by nature and training for their tasks, in the right places, at the right time, and with the right training, guidance, direction and supervision."

This statement was made in a paper on the "Scientific Selection and Assignment of Men in the Creation of an Organization," by Dr. Katherine M. H. Blackford before the last annual meeting of the Efficiency Society. It was spoken of all lines of endeavor impartially, but it could hardly have fitted more exactly had it been said specifically of the field of power-plant engineering. We wish that we might get the truth of this statement home to the owners and managers of all power plants. From time to time we have remarked how inconsistent it is to lay out large sums of money for the finest power-generating equipment and then put it under the charge of incompetents. We have said it so many times ourselves, we are glad to give it in the words of another in the hope of emphasizing it, particularly when given, as in the original of this case, as a universal fact.

We have no comments to make on the main issue of the paper quoted from as to how the best adapted workers may be selected, not by "hit-and-miss" or the "hiring-and-firing" methods, but by scientific analysis of their characters and qualifications. It is a deep subject and one destined to mean much to the material progress of our industries in the next decade.

So far as the selection of power-plant engineers and their helpers is concerned it would not seem that there should be any serious difficulty in the way. In states having license laws (may their number increase) there is the means at hand to determine the man's qualifications of knowledge and experience. Common sense and the study of mankind enable a decision as to suitability of character.

Wherein then is the difficulty? Is the supply of capable operating engineers insufficient for the demand? (Some claim they cannot get the right men.) We are not prepared to answer the above question. In some localities there may be, probably are, plenty of good men available, and in others the reverse may be true. This we know: When the remuneration paid operating engineers is more nearly commensurate with what is expected of them, as judged by comparison with other professions, there will be no lack of material. Make the field more attractive and it will not be a great while before it is crowded.

This much may be said of the situation at present. Those now engaged in this line of work are in it for the love of the work—not the love of the pecuniary return.

Power-Plant Emergencies

Power-plant operation, when everything is going smoothly, calls for just watchfulness on the part of the operator or, in other words, merely ordinary routine work. This is why so many steam plants, which are in reasonably good condition, can be operated for months by a man who is not entirely competent and who is not big enough for the position when anything of a serious nature does occur.

It is the unexpected happenings in power-plant operation that show up the ability of the men in charge and often call for quick work in making temporary repairs to maintain the service. An instance of resourcefulness in time of difficulty to minimize disastrous consequences is to be had in an experience at the Shreveport, La., power plant.

Two accidents occurred in succession: The first was the collapse of an extension of the engine room, which left the switchboard exposed to the elements, but it was protected as soon as possible by a temporary wooden inclosure. About a month later a short-circuit on the high-tension line at the switchboard ignited the temporary wooden shelter. From this the fire spread throughout the engine room, putting out of commission all but one of the four generating units, by destroying the belts driving them. All of this happened within not more than fifteen minutes.

Here was a situation to try the ingenuity of those in charge. The business section, containing over thirty-five thousand people, depended upon this plant for electrical energy, and everything was at a standstill for want of belting. The superintendent of the electrical department decided that pieces of scrap belting could be used to repair such parts of the generator belts as were not completely destroyed, and by daylight the following morning, two power circuits were in service and the lighting circuits were cut in a few hours later.

While this repair work was being done an order for belting was sent and the shipment was received six days after the fire. A new switchboard was also ordered and shipped twenty-one days from the date of the order. Inside of three months the plant which had been wrecked by the collapsing of the walls and by fire was giving regular service to its patrons.

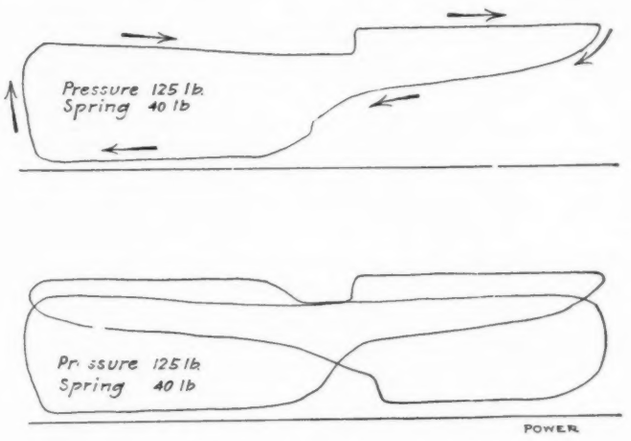
Such occurrences as these bring out the best there is in those in charge. Although the strain and anxiety may be wearing, and many hours of hard work necessary, there is after all a satisfaction in the knowledge that the difficulties have been met and the obstacles overcome.

As showing how our German cousins can entertain, the account of the joint meeting of the Verein deutscher Ingenieure and the American Society of Mechanical Engineers given on a later page is interesting. These joint meetings contribute much to engineering progress as a direct consequence of the papers and discussions at the professional sessions. No doubt, those fortunate enough to attend reap the largest benefit, by seeing the foreign engineering works and meeting those of other nations engaged in kindred pursuits, but there is no measuring the number of people, engineers and others, in both nations, who indirectly profit to some extent. The good fellowship created by such meetings of the various professions has a deeper significance than many realize.

READERS WITH SOMETHING TO SAY

Diagrams from Jet-Condenser Pump

The illustrations show diagrams from the steam end of a jet-condenser pump. The single diagram was taken from the frame end and the arrows show the direction of the pencil travel. The indicator was connected to the drips. The pump was making about 80 strokes per minute and carrying a 24-in. vacuum in the condenser head.



DIAGRAMS FROM JET-CONDENSER PUMP

The diagrams show clearly the extent of the jump at the beginning of the stroke and also show the error that may be made by studying the diagram from one end alone when finding the power applied. By examining the single diagram it looks as though the larger amount of power was used at the beginning of the stroke while a study of the double diagram shows that the larger amount of power is used on the last half of the stroke.

LESTER A. FITTS.

Leominster, Mass.

Broken Pipe Fitting Damages Engine

When I arrived at the plant one morning, the night engineer reported that one of the engines was badly damaged. He said that it had been running as usual, when, without warning, the smashup occurred.

The engine was a small 9x10-in. automatic, running at 350 r.p.m. Upon examining it, I found the valve rod doubled up, the rocker-arm broken off, the eccentric rod badly bent, the oil guard smashed and the bolt holding the eccentric to the governor arm sheared off. I removed the steam-chest cover and found a small piece of an elbow that had caught endwise between the edge of the valve and the wall, preventing the valve from moving farther, causing the damage as a result.

I assume that a pipe fitter had broken a fitting, a piece of which had fallen inside the steam pipe and had been forgotten, finally working its way along to the engine with the results stated. As there had been no work done on any of these lines in the last two years, the piece had been in the line that long or longer.

Now, I know that I have often broken a fitting when I was in a hurry or when it was necessary and I have no doubt other engineers have done the same. This accident will cause me to be a little more careful in the future.

ARTHUR V. LACY.

Julietta, Ind.

Fuel Costs Reduced

The price of coal at the present time is such that engineers in charge of power plants are ever on the lookout for some new device or idea which will enable them to reduce the coal costs. The writer is in charge of a central station with an output of about 1,500,000 kw.-hr. per annum. During the summer months we have very little load, which means that we have to run the engines light several hours each day, as we must have current on the line and stand ready to serve. This brings our coal costs very high per unit generated during the summer months.

We were sure that in spite of our poor load factor the firemen could do much better if they would only take an interest in their work. The problem was how to get them interested. We have had a large notice board put up in the boiler house and on squared paper we plot the units generated, and the cost of coal per unit generated each week.

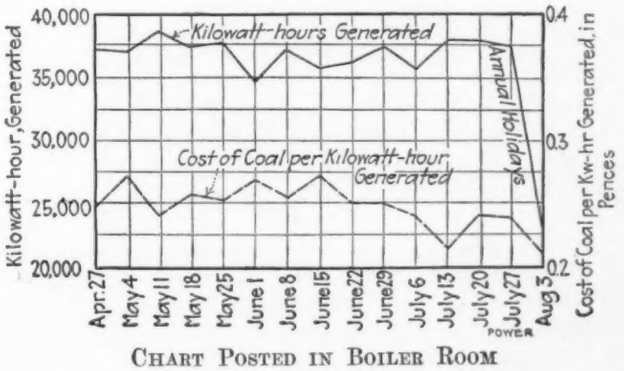


CHART POSTED IN BOILER ROOM

The chart was posted in the boiler house sometime ago and we are more than pleased with the results. A notice is posted each week with remarks about the curve and the quality of coal, etc.

The average coal cost for May and June was 0.257 pence per unit generated while the cost for July was down to 0.232 pence.* The firemen and others in the plant are taking a great interest in the chart and we are confident that they will bring the cost lower still. The saving in July over May and June is 0.025 pence per unit generated and this taken on 1,500,000 units per annum

*One pence equals 2 (U. S.) cents, or 2.03 cents, to be exact.

accounts for £150 ($750). Nothing has been done in any way to improve the efficiency of the plant, the saving being due entirely to the efforts of the men and the firemen in particular. The initial outlay is nothing and in our case the saving is well worth the trouble.

A CO_2 recorder is now installed and a CO_2 curve will be plotted on the chart. This will lend additional interest to the chart and it will also reveal who is responsible for low CO_2 percentages.

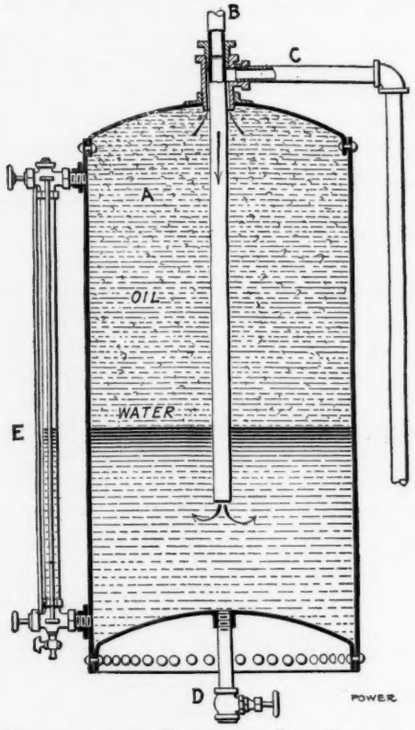
F. Riley.

Manchester, Eng.

A Simple Oil Separator

We have a home-made gravity-oiling system very much the same in general principles as other gravity systems using compressed air for delivering the oil from one height to another.

We, however, encountered one difficulty which was very annoying, that was the condensation in the air pipes accumulating in the gravity tank. This water would come



A Simple and Positive Oil Separator

down with the oil in slugs and give trouble in lubricating the bearings. After two or three experiences with hot bearings, due to this water, we designed the separator shown.

The tank or drum *A* of the separator is of convenient size, holding perhaps 10 gal. and is connected in the main delivery line leading from the gravity tank, the pipe *B* being the inlet which is extended to within 6 or 8 in. of the bottom. The pipe *C* connected to the top of the tank is the outlet. A gage-glass *E* is fitted to the side, as shown, and shows at a glance the amount of water collected. The separator is located at a convenient place near the floor so that the water may be drawn off as often as is necessary by opening the valve *D*.

A. S. Peterson.

Shawnee, Okla.

Examination Questions; First-Class N. Y. City License

Where should the feed-water connection be placed on a boiler? Why?

How would you determine the size and number of stay-bolts to be used in a boiler?

How many cubic feet of steam at atmospheric pressure weigh one pound?

How is a hard patch put on a boiler, and when, due to its position, cannot it be riveted?

How far apart should ¾-in. rivets be spaced on a boiler?

How should the gage-glass be put on a boiler?

If too little air was admitted into a furnace, what would be the result?

State all the advantages of superheated steam?

How would you find the total stress or strain on a flat surface held by stays?

Draw an indicator diagram one stroke only, showing expansion line, effect of leaky piston, admission line, leaky valves and too much compression?

What is the horsepower of an engine 16 in. in diameter, 32 in. stroke, 80 lb. pressure and 90 r.p.m.?

State the difference in action between the throttling governor and the automatic governor?

What is a cam? What is its use?

How would you proceed to set a piston valve?

State the advantage of the drop cutoff in Corliss engines over the riding cutoff in other engines?

Why is the economy of an engine never expressed in pounds of coal?

What is meant by initial pressure?

What is the advantage and disadvantage of a keyed eccentric?

Is it possible to maintain a perfect vacuum in an engine?

Is it advisable to lift the brushes off the commutator while it is in motion?

Can a commutator be taken off when worn?

What causes a dynamo to motorize?

If part of the insulation should be worn off a live wire some place in the line and the wire came in contact with metal, what would happen?

What causes the brushes of a dynamo to spark?

How would you know when to move the quadrant of a dynamo?

How do you determine the head pressure of an ice machine?

State the difference between single- and double-acting ammonia compressors?

What is meant by the terms ammonia-absorption plant; brine system; direct-expansion system?

What is the function of the pressure tank, and to what part of the plant is it connected?

What causes ammonia compressors to burst?

Frederick G. Lemke.

New York City.

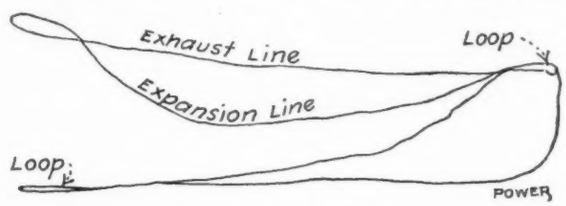
[The above is of interest only as showing the *character* of questions asked. Few, if any of them, are likely to be asked again, hence one needs to understand the subjects involved rather than to know the answers to these specific questions.—Editor.]

QUESTIONS BEFORE THE HOUSE

Comment on Freak Diagrams

In POWER, June 17, page 869, John T. Sharp, Jr., asks for comment on indicator diagrams submitted.

To begin with, the diagrams are not complete since the atmospheric line is absent. Examination of the diagrams under a glass shows a loop on both ends of one diagram and one loop at the exhaust on the other. The loop at the exhaust end of the diagram with two loops, as indicated in the illustration, is caused by the whole of the expansion line being below the exhaust line, and is



SHOWING IMPERFECT DIAGRAM

not caused by too early cutoff, as is the case with the card showing only one loop.

The upper line of the diagram with two loops I believe represents the exhaust line, and the lower line is the expansion line. This was caused by the motion of the indicator drum being interfered with somehow. Possibly someone took hold of the cord or something fell on it and threw it out of time with the events of the stroke, and the diagram was made before all the events of the stroke was completed.

The drum should have been turning to the left when it was turning to the right. This gives initial pressure of exhaust, which the diagram with two loops shows. I believe that the position of the diagram with two loops, i.e., relative to the position of the other diagram, is due to the card being moved on the indicator drum after the diagram with one loop was taken and before the other was taken. A 70-lb. spring was too strong. For the pressure, a 30-lb. spring would have been strong enough.

THOMAS C. ROBINSON.

Fort Madison, Iowa.

❋

Slippage of Reciprocating Pumps

Referring to Mr. Newbold's comment on the above subject, page 792, June 3 issue, Mr. Newbold is in error when he believes that crank pumps do not have the "get-away" action of the direct-acting pumps, thus allowing more time for the valves to "nest home." Just the opposite is true. It is a peculiarity of the duplex pump, that the pistons remain at rest at the end of a stroke for a certain time (about ⅛ of the time required for one stroke), allowing the valves to come down to the seats. With flywheel pumps the piston reverses instantly and for this reason, power pumps must be run slower than duplex pumps or must have larger valve area; otherwise, the valves will slam and produce objectionable results.

A. REDDING.

Buffalo, N. Y.

❋

The Engineer's Chair

In the June 17 issue of POWER there appeared an editorial under the heading, "The Engineer's Chair," which I found particularly interesting. However, I cannot entirely agree with the conclusions arrived at. The general proposition that an engineer who has to be kept continuously on his feet, to make sure that he will attend to his work properly, ought not to be trusted with the care of a plant at all, sounds well enough, and I believe, myself, that any rule specifically forbidding the man on duty in the engine or boiler room from sitting down when he is not needed on his feet is foolish. Nevertheless, experience has convinced me that it is a serious mistake to put chairs or other furnishings in the average engine room in such numbers or of such a kind as to invite the attendant to sit down or to make sitting too comfortable for him; especially is this so in plants which run at night.

A few years ago, I was fireman and assistant engineer in an electric-lighting and power plant where the load was so light during the Christmas week that it was usually not necessary to keep more than one man on duty at a time. During this period, the two of us who were ordinarily on duty together every night would take turns about in keeping things going, each of us thus getting every other night off. Returning to town about 1 o'clock on one of these nights, I was surprised to find that every incandescent lamp that I could see had its filament just barely glowing. A few minutes later I discovered the engineer fast asleep on an old sofa which we had brought into the engine room from a club house in the neighborhood. He had 40 lb. of steam and not a drop of water in the boiler gages. This man was a good, dependable engineer, but he said that when he sat down to rest for a moment, he fell asleep before he realized that he was even sleepy.

In a later experience of mine, the day man in a plant of which I was in charge, exercised his ingenuity in some of his spare moments in making what was the best model of comfort I have ever seen in the way of a chair constructed of rough boards and course bagging. In spite of my misgivings, I allowed this thing to remain in the engine room, only to be called out of bed at 4 o'clock a few mornings later with the cheerful news that both the main bearings and the crank bearing on a large engine had been burned out. The nap for which the presence of that chair was mainly responsible cost us at least $1000 before the damage was all repaired.

As to reading in the engine room, like the writer of the editorial referred to, I believe in encouraging the operating engineer to read technical journals. It is a mighty poor sign when an engineer is not sufficiently in love with

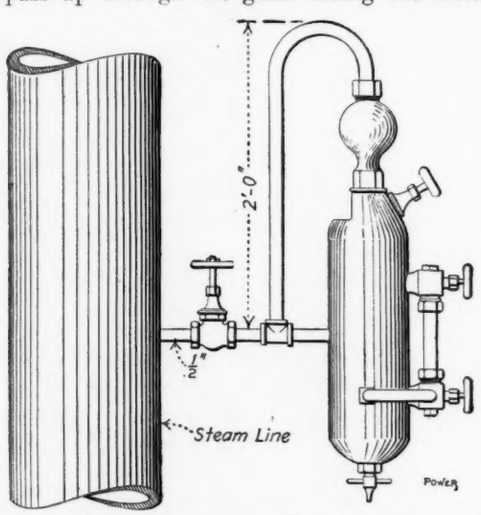
his chosen work to read all of these that he can. But, in my opinion, the engine room is not the place to read. A good man can usually find enough to do to leave him but little or no time for chair warming and reading in his regular working hours.

J. E. LATTA.

Chicago, Ill.

What Becomes of the Water

Mr. Thurston, in POWER, June 17, page 869, states that he is having trouble with his sight-feed lubricator on account of the water leaving the glass when the engine is shut down. I have had similar trouble with two vertical 7x7-in. piston-valve stoker engines. These engines are connected to a fan, one on each end, one being used at a time. They are controlled by a balanced valve on the steam line which is connected to the damper regulator. The engine runs very intermittently, from 140 to 450 r.p.m. There was a single-connection lubricator connected to each engine between the regulating valve and the cylinder. Every time the steam was cutoff by the damper regulator, bubbles, which appeared to be air, would pass up through the glass taking the water with



UNUSUAL CONNECTIONS FOR DOUBLE-CONNECTION LUBRICATOR

it, and the oil would pass through the needle valve in a stream, although when the engine was running or after it had slowed down no trouble was given in feeding the oil. I think the reason was, in this case, that a vacuum was formed in the steam line, as the engine ran at high speed several seconds after the steam was shut off, due to the momentum of the heavy fan. This not only caused the water to evaporate, due to reduced pressure, but may have drawn some air in around the glass packing, which in passing through the glass, took some of the water with it. Possibly the design of the lubricator had something to do with it. One of the engines still gives the same trouble. The other one was stopped by changing the lubricator.

The steam pipe to which the lubricator is connected is vertical and a double-connection lubricator was put on but not in the usual manner. The accompanying sketch shows the double-connection lubricator connected to one connection in the steam line. There is a short ½-in. nipple screwed into the steam line with a valve, a second nipple, a tee, and another nipple to which the lubricator is connected. The loop from the tee to the top of the condensing chamber is about 2 ft. high. This lubricator gives absolutely no trouble, and has been in use nearly a year. It was put on in this manner because it was impossible to turn the steam off long enough to drill and tap a hole for the top connection.

A double-connection lubricator usually gives better satisfaction than a single connection, possibly that is partly the reason why the trouble was stopped when we made the change. Incidentially it might be said that this manner of connection is a satisfactory one in which a double-connection lubricator may be used on a horizontal pipe. In regard to Mr. Thurston's trouble, my impression is that it is due to evaporation, and vacuum, and if the practice of closing the valve in the oil line to the cylinder stops it, that is the way I would shut down.

J. C. HAWKINS.

Hyattsville, Md.

Mr. Thurston's trouble with the water disappearing from the sight-feed glass of a lubricator, as related in the June 17 issue is very similar to an experience I once had.

Shortly after taking charge of a new plant, I noticed that every time I made my rounds I found the lubricator on a certain engine empty. I called the oiler's attention to it, and he told me that none of the oilers had been able to keep any oil in that lubricator. On examining the lubricator more closely, I found the trouble to be in the way it was connected. Both connections entered the steam pipe below the throttle, and as soon as the throttle was closed the vacuum took the oil and water out of the lubricator. The only remedy was to close both connections to the lubricator before closing the throttle.

I think if Mr. Thurston will investigate the throttle valve closely he will find that the disappearance of water from the sight-feed glass is due to the vacuum, and not to evaporation, as he seems to think.

S. F. FARLEY.

Galveston, Tex.

Cause of Corroded Tube Ends

In answer to Sydney Whitaker's letter, in the June 17 issue, relative to corroded ends of boiler tubes would advise that I have had similar experiences and I have come to the conclusion that when tubes were put in they were rolled too hard and sheared, or cut slightly and corrosion started more easily on account of flues weakened condition. I think if engineers would use a bushing and a little judgment and less muscle when using the expander there would be less sheared and leaky flues.

Breckenridge, Mo. ANDREW BLAIR, JR.

[It is claimed by some well versed in the study of metals and corrosion that weakened steel or iron is more subject to corrosive agents than metal that has not been strained.—EDITOR.]

Why Engines Rock

Replying to H. R. Low in the issue of July 1, I would advise that excessive rocking of an engine in most cases is caused by too much compression. The remedy is obvious.

Louisville, Ky. JOHN F. HURST.

INQUIRIES OF GENERAL INTEREST

Safety-Valve Setting—How can it be determined at what pressure a safety valve is set to blow?

R. B.

By testing with hydrostatic pressure, i.e., filling the boiler with water and pumping in more with a hydrostatic test pump until the safety valve opens. The pressure then shown by the gage on the pump will indicate the valve setting.

Metal Melting Points—What are the melting points of babbitt and zinc?

A. C. H.

Zinc melts at 786 deg. F. Commercial babbit metal is made in a variety of proportions of copper, antimony, zinc and frequently lead with an average melting point of about 1000 deg. F.

Rate of Spring Flow—What is the best way to measure, approximately at least, the rate of flow of water from a spring?

W. K. G.

The best and most convenient way is to measure the discharge by a weir. A complete description of the construction and use of weirs is given in "Power," Dec. 28, 1909, pages 1090-1094.

Exhaust Steam Heating Better—We are heating the mill with live steam at 90-lb. pressure, saving the returns for boiler feeding. Is this more economical than using exhaust steam?

G. W.

Exhaust steam would be more economical for heating than live steam, but the piping must be large enough to deliver the steam at the lower pressure.

Turbine vs. Engine Economy—How does a 300-hp. turbine compare in economy with a four-valve high-speed engine of the same rating, both exhausting to the atmosphere and operated at full load?

G. W.

A 300-hp. turbine of average good construction exhausting into the atmosphere, would be about half as economical as an average good noncondensing four-valve engine.

Boiler-Tube Ends—Why should water tubes be flared at the ends, while fire tubes are beaded?

R. B.

Fire-tube boilers should have the tubes beaded over at the ends to insure that the tubes stay the flue sheets or heads of the boiler. It is sufficient to simply flare the tubes of a water-tube boiler as the reacting-pressure area to be supported is less per tube, amounting to only the cross-sectional area of the tube.

Hydraulic Accumulators—Why is it necessary to have an accumulator on a hydraulic system? Would the system not work without one?

E. J. M.

It is necessary to have an air-pressure accumulator or else a weighted plunger accumulator in a hydraulic system to maintain steady pressure. Pumping directly into the system would not insure steady working pressure. Using an accumulator not only makes steady pressure, but also permits of using the system to a considerable extent without running the pumps—depending on the capacity of the accumulator.

Hard and Soft Patches—What is the difference between a hard patch and a soft patch?

E. S.

The term "hard patch" signifies that a boiler patch is riveted in place, usualy being put on the inside of a boiler shell for covering a hole made by removing a bad spot in the shell.

"Soft patch" is the name given to a patch which is carefully shaped to the space to be covered and goes on the outside of the boiler. Usually the patch is held in pace by screw bolts or cap screws which are screwed into holes tapped into the boiler shell. The screw bolts are usually collar-head cap screws and the square heads are chipped off after the bolts are set up, leaving the collars to hold the patch to the shell. Soft patches are frequently used to cover cracks in boiler shells and the fact that soft copper or lead is generally used as a packing between the patch and the boiler shell is the probable reason for calling a repair of this kind a "soft patch."

Safety-Valve Area—How would you determine the required area of a safety valve for a given boiler?

R. B.

The U. S. inspectors' rule for area of all safety valves determines the area by the formula:

$$a = 0.2074 \times \frac{W}{P}$$

where

a = The area of safety valve in square inches per square foot of grate surface;
W = The pounds of water evaporated per hour per square foot of grate surface and
P = Absolute pressure per square inch (working gage pressure + 15).

The value of "a" multiplied by the square feet of grate surface gives the area of safety valve or valves required.

Economical Cutoff—We have a 500-hp. engine which cuts off at half-stroke when developing this power. Our load is constant and 250 hp. Would it be more economical for us to get an engine whose rated load is 250 hp. when cutting off at half-stroke?

E. M. W.

No. From a table of mean forward pressures it can be found that for the above conditions and at half stroke the mean forward pressure is 0.8556 lb. per lb. of initial pressure, assuming 5 per cent. clearance. Assuming 100 lb. abs. initial pressure the mean forward pressure would be 85.56 lb. Also, assuming 17 lb. absolute back pressure, the mean effective pressure would be 68.56 lb. For half the load the mean effective pressure would be

$$\frac{68.56}{2} = 34.28 \text{ lb.}$$

Adding the 17-lb. back pressure the mean forward pressure would be 51.28 lb. or 0.5128 lb. per pound of initial pressure, which from the tables is found to correspond to a cutoff of less than $\frac{3}{16}$-stroke and a little more than $\frac{1}{8}$-stroke. In any event it shows that less than half the steam will be admitted per stroke and, speed remaining the same, the steam consumption will be less than it would with cutoff at half-stroke.

Tank-Head Strength—The bumped head of a cylindrical tank is $\frac{3}{8}$ in. thick, 30 in. in diameter, the radius of curvature is 30 in. and the tensile strength of the material 60,000 lb. per sq.in.; with a factor of safety of 4 what is the safe working pressure?

R. J.

The ultimate strength can be found from one or the other of the following formulas:

$$p = \frac{2St}{r} \quad \text{or} \quad p = \frac{2St}{d}$$

where

S = Tensile strength, pounds per square inch;
t = Thickness of the material;
r = Radius of curvature of the head;
d = Diameter of the head.

The right formula to use in any case is the one in which the value "r" or "d" is the larger. In this instance they are equal, hence either formula will do and to get the working pressure for a factor of safety of 4 it is necessary to divide "p" by 4 and since

$$p = \frac{2St}{r}$$

$$\frac{p}{4} = \frac{2St}{r4} = \frac{2 \times 60{,}000 \times 0.375}{30 \times 4} = 3750 \text{ lb. per sq.in.}$$

ENGINEERS' STUDY COURSE

Heat Lost in Flue Gases—III

SOLUTION OF PRACTICE PROBLEMS

The percentage of excess air supplied to the furnace may be determined from the formula for calculating the ratio of air supplied to air required, which is as follows:

$$R = \frac{N}{N - (3.78 \times O)}$$

From the data given, N, the percentage of nitrogen in the flue gas, equals

$$100 - (6.3 + 11.7 + 0.4) = 81.6$$

Substituting in the formula gives

$$R = \frac{81.6}{81.6 - (3.78 \times 11.7)} = \frac{81.6}{37.37} = 2.18$$

Thus, 2.18 lb. of air was supplied for every pound theoretically required. Hence, the amount of excess air supplied with each pound required is

$$2.18 - 1 = 1.18 \text{ } lb.$$

This excess amount divided by the required amount and multiplied by 100 gives

$$\frac{1.18}{1} \times 100 = 118 \text{ } per\ cent.$$

excess air supplied to the furnace.

To calculate the B.t.u. carried up the chimney by the flue gases per pound of coal burned it is first necessary to estimate the weight of flue gases formed per pound of coal. And before this quantity can be estimated it is necessary to estimate the decimal part by weight of total carbon in the fuel. The decimal part of fixed carbon is given (expressed as a percentage) in the promixate analysis of the coal, and equals 0.652. To this must be added the decimal part of volatile carbon, which is estimated in the manner explained in the lesson of July 22 by means of the chart in Fig. 1. The sum of the percentages of fixed carbon and volatile matter is 65.2 + 18.6 = 83.8, and this, divided into the percentage of volatile matter and multiplied by 100, gives

$$\frac{18.6}{83.8} \times 100 = 22.2$$

the percentage of volatile matter in the combustible.

Locating as closely as possible the 22.2 per cent. point at the bottom of the chart in the July 22 number, and tracing an imaginary line up to the curve and over to the side scale, we get 10.4, the percentage of volatile carbon in the combustible. And this, multiplied by the percentage of combustible in the coal (83.8) and divided by 100, gives

$$\frac{10.4 \times 83.8}{100} = 8.7$$

the percentage of volatile carbon in the coal. Shifting the decimal point two places to the left reduces this percentage to a decimal fraction. Adding this fraction to 0.652, the decimal part of fixed carbon in the coal, gives

$$0.652 + 0.087 = 0.739$$

or practically 0.74, which is the decimal part of total carbon in the coal.

The formula for estimating the weight of gases formed per pound of coal burned is

$$W = 3.032\ C \left(\frac{N}{CO_2 + CO}\right) + (1 - A)$$

Substituting, gives

$$W = 3.032 \times 0.74 \left(\frac{81.6}{6.3 + 0.4}\right) + (1 - 0.117)$$

$$W = 2.24 \left(\frac{81.6}{6.7}\right) + 0.88 = 28.16 \text{ } lb.$$

gases formed per pound of coal burned.

The B.t.u. carried up the chimney per pound of coal burned is estimated by this formula.

$$L = 0.24\ W\ (T - t)$$

Substituting, gives

$$L = 0.24 \times 28.16\ (515 - 75)$$

$$L = 6.76 \times 440 = 2974 \text{ } B.t.u.$$

carried up the chimney by the flue gases per pound of coal burned.

The percentage of loss is the number of B.t.u. carried up the chimney per pound of coal divided by the heat value of the coal and multiplied by 100, thus

$$\frac{2974}{13{,}160} \times 100 = 22.6 \text{ } per\ cent.\ loss$$

There are several ways in which the answer to the last problem can be obtained. The simplest, although, perhaps, not the shortest, is to find the percentage of heat loss in the second case and subtract this loss from the loss we have already worked out for the first case. The difference, divided by the heat value of the coal, will represent the percentage of coal saved per year. Then, the number of tons thus shown to be saved, multiplied by the cost per ton, will give the annual saving in dollars and cents.

First, using the formula for the weight of flue gases formed, gives

$$W = 3.032 \times 0.74 \left(\frac{81.6}{10.7 + 0.4}\right) + (1 - 0.117)$$

$$W = 2.24 \left(\frac{81.6}{11.1}\right) + 0.88 = 17.34 \text{ } lb.$$

the weight of flue gases formed per pound of coal.

Next, substituting this value in the formula for estimating the heat lost up the chimney, gives

$$L = 0.24 \times 17.34\ (515 - 75)$$

$$L = 4.16 \times 440 = 1830 \text{ } B.t.u.$$

carried up the chimney by the flue gases per pound of coal.

In the first case, 2974 B.t.u. was lost up the chimney per pound of coal. Hence the saving is

$$2974 - 1830 = 1144 \text{ } B.t.u.$$

per pound of coal. In percentage this saving amounts to

$$\frac{1144}{13{,}160} \times 100 = 8.69 \textit{ per cent.}$$

As 8.69 per cent. of each pound of coal is saved, 8.69 per cent. of each ton and hence 8.69 per cent. of all the coal is saved. Thus, the saving in tons per year equals

$$\frac{6200 \times 8.69}{100} = 538.78$$

and the saving in dollars and cents equals

$$538.78 \times 3.10 = \$1670.22$$

Loss Due to Incomplete Combustion

In one of the early lessons we learned that carbon under certain conditions will only partially burn, forming carbon monoxide (CO) instead of carbon dioxide (CO_2) and creating only 4450 B.t.u. per lb. of carbon instead of 14,600. Hence, for every pound of carbon only partially burned

$$14{,}600 - 4450 = 10{,}150 \textit{ B.t.u.}$$

is lost.

If the flue-gas analysis shows that CO exists it may be important or desirable to know the amount of heat loss due to incomplete combustion. The following formula is convenient for estimating this quantity.

$$L' = 10{,}150 \left(\frac{CO}{CO + CO_2} \right) C$$

Where

L' = B.t.u. lost per pound of fuel;
CO = Percentage by volume of carbon monoxide in the flue gas;
CO_2 = Percentage by volume of carbon dioxide in the flue gas;
C = Decimal part by weight of total carbon in the fuel.

To illustrate, assume the following: CO, 1.3 per cent.; CO_2, 15.2 per cent., and total carbon in the fuel, 72.8 per cent. The heat loss due to incomplete combustion would be, in such a case,

$$L' = 10{,}150 \left(\frac{1.3}{1.3 + 15.2} \right) 0.728$$

$$L' = 10{,}150 \times \frac{1.3}{16.5} \times 0.728 = 582.27 \textit{ B.t.u. per lb.}$$

Control Board for Panama Locks

The first of the control boards for the Panama Canal locks has just been completed by the General Electric Co. Before shipping to the canal zone, however, it was assembled and a demonstration of its operation given before a number of guests at the Schenectady works on July 28.

The board is of the bench type, about 60 ft. long, and is unique in that its top represents a plan of the locks with all the gates, etc., in miniature; these operate simultaneously with the actual gates. A system of water-level indicators is provided, as well as signal lights showing the positions of the valves.

By an ingenious system of interlocking the operator is prevented from throwing any of the switches in the wrong sequence, which makes the board practically foolproof.

At a later date we hope to illustrate and describe the board more in detail.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"A boiler explosion broke the right leg of Rufus Palmer last Friday, on the farm of Robert Liddell, northeast of Columbia, where Mr. Palmer was threshing wheat," says the Columbia (Mo.) "Herald." Beats all how a boiler explosion sometimes cuts up. It might be some consoling that the dratted thing broke the right leg, whichever one that was.

This comes from Kansas: "Farmer David Rump has a calf that is 16 in. high." Goodness only knows what a boiler explosion would do to Dave's calf. From the meager press details, one is at a loss as to whether Dave ought to cover his calf with a pink silk sock, or tether it out in the red clover and let it bark at the passing automobiles.

Out of 10,000 names in a straw vote as to "the most useful American," Thomas A. Edison received 87 per cent. of the ballots cast. It's not surprising that Edison should get this recognition. A woman, Jane Addams, was second choice. For years, remarks "Valve World," this noble woman has been quietly putting into practice "a human method of helping the poor"— and helping them to help themselves. In its own grooves, this work is as great as that achieved by Edison.

My stars! Efficiency is now roaring up into the blue vaults of high heaven—gone up in the air, as it were. The leading astronomers are adapting its methods to their particular needs. Now who will tackle the bottom of the sea and stir up our old friend McGinty?

A man in Oklahoma thinks that "the boiler explosion was caused by too much pressure in the boiler." It's a pretty good guess at that, unless the boiler may have become infested with boll weevils.

Hoch Deutschland! Hoch der American Society of Mechanical Engineers! Those who attended the recent international convention at Leipzig had the time of their lives and they live to tell it. On arrival, their hospitable German hosts took them to their hearts—and to the Hofbräuhaus. In fact, the 18 days' visit was a succession of banquets and lunches, 28 in all—a regular endurance test. But in between they saw things and learned things that will endure for a lifetime. They're glad they tore themselves away from Yankeeland that they might dip into the good things of the Fatherland.

The Congressman electrician who proposes the installation of an electric voting machine in the national House lays himself open to the suspicion of pernicious activity. He would record his vote by pushing a button. In a hotel café this is productive of the desired results, but it is prostituting congressional dignity to attempt it in the House.

Can you dope this out as you read it? "A man leaves his working face before shooting time, expecting his buddy to fire all the shots, but the buddy is injured by a windy shot and can't make his way out," says "Coal Age." This partly describes a coal-mine accident; it's the slang technique of the miner.

"Pencil scribblings no longer deface the walls of our toilet rooms," reports a shop manager in "Factory." Oh ye poets and cartoonists, what a blow to an active industry! Friend manager has dealt this blow by removing the stall doors; the frequenters are, therefore, under more or less surveillance.

The digging is always good in Rome, Italy. Apparently, if one is hazy as to the origin of any old kind of engineering, he has simply to take a Roman excavation trip—and he's got it. In the first century Roman houses were heated by a primitive system of hot-air circulation; there were three large elevators in the Imperial Palace; there were hot- and cold-water services—mebbe, the early wise guys knew if the foot-pound wabbled. The pick and the shovel have heretofore been belittled by the ignorant and the thoughtless;; now it's time to buck up.

Mechanical Engineers' German Meeting

By F. R. LOW

Notable among the increasingly frequent international exchanges of courtesy is the entertainment extended by the Verein Deutscher Ingenieure to the members of the American Society of Mechanical Engineers who accepted the invitation to take part in its summer meeting at Leipzig. The visiting party numbered upward of 300, most of whom left New York on the "Victoria Luise" on June 10.

Representatives of the Verein boarded the ship at Plymouth, England, to welcome the visitors and explain the arrangement which had been made for their comfort, convenience and entertainment.

Being somewhat behind her schedule, the "Victoria Luise" landed her passengers at Cuxhafen, whence they proceeded by train to Hamburg where they arrived late in the evening of Thursday, June 20.

AT HAMBURG

On Friday forenoon the company assembled at the Landing Stage Restaurant of the river steamers where after breakfasting they listened to a lecture about the Harbor of Hamburg and the tunnel under the Elbe by Geheimrath Bubendey who is responsible for much of the recent work, and then took an excursion about the harbor in steamers.

In the evening a reception was tendered to the visitors by the Senate of Hamburg, which is one of the free cities, a miniature republic with a government of its own. The address of welcome was made by the Lord Mayor, and an opportunity was offered to inspect the magnificient Rathaus, the seat of the local government. A banquet tendered by the Hamburg Section of the Verein Deutscher Ingenieure in the Rathskeller beneath the same building completed the evening's entertainment.

On Saturday the tunnel under the Elbe, a municipally owned project with two driveways and two sidewalks, and with elevators at either end for teams and passengers was inspected. It was a pleasure to notice that the elevators were American, made by Otis. The party was then taken to the ship-building yards of Blohm & Voss where among other interesting things the "Vaterland" (55,000 tons, five tons larger than the "Imperator") was on view. After lunching at the yards the party was taken to the power station of the elevated railroad at Barmbeck whence after being further refreshed they proceeded to the Hagenbeck Zoological gardens, the attractions of which were explained by the younger Mr. Hagenbeck himself. The evening was thoughtfully left free and profitably employed in viewing the interesting points of the city itself.

AT LEIPZIG

Sunday the 22d was spent in going from Hamburg to Leipzig where the party arrived late in the afternoon, in time to witness the flight of several Zeppelins. Here the attendants at the Leipzig meeting were already assembled and the first union of the guests with the greater body of their hosts took place at a tremendous reception at the Crystal Palace. I use the word advisedly for everything, company, place and entertainment was upon a large and generous scale, and of an informal character which afforded an excellent opportunity for the initial amalgamation.

On Monday morning the opening session of the general meeting of the Verein Deutscher Ingenieure was held in the Central Theater and it is an index of the esteem in which the engineer and this his professional organization are held in Germany that H. M. the King, Friedrich August of Saxony.

ONE OF THE TEN AUTOMOBILES USED IN THE DRIVE TO WANNSEE, JUNE 28

was pleased to be present and to be "promoted" to Doctor of Engineering. Count Zeppelin was also there and spoke briefly and the Grashof medal was awarded to George H. Westinghouse.

At the conclusion of the award of honors, Dr. Lamprecht presented a paper upon the "Technical Science and Culture of the Present," and Dr. W. F. M. Goss' paper upon "Influences Affecting American Engineering Practice" (abstracted in "Power," July 1, 1913, page 38) was presented in Dr. Goss'

A GROUP OF THE ENGINEERS AT THE WORKS OF THYSSEN & CO., MÜLHEIM, GERMANY, JUNE 30

absence by Past-President Jesse M. Smith. One of the most enjoyable features of the whole trip was a concert at the Gewandhaus tendered by the Senate of the city of Leipzig by an orchestra of nearly 100 pieces. This was followed by a banquet in the large festival hall of the Central Theater, in the course of which several numbers were rendered by the Thomaner-Boy Chorus founded by J. Seb. Bach.

Tuesday's session of the Verein was held in the lecture room of the Architectural Exhibition, there in progress. Opportunity was afforded to view the exposition, to visit several local industries and to take part in the dedication of the monument to the "Battle of the Nations." The evening party at the Palm Garden was somewhat disorganized by a violent

thunder storm, especially the intended celebration of the Solstice on the lawn and the illuminations and fireworks.

AT DRESDEN

Leaving Leipzig the party arrived at Dresden before noon, and at two o'clock was taken to the Bastei (the Switzerland of Saxony) returning as far as Pirna by steamer on the Elbe and thence to Dresden by special train. In the evening a reception and banquet were given the visitors in the Town Hall by the city of Dresden.

The following forenoon was devoted to sight-seeing. At the Mechanical Engineering Laboratory of the Technical High School, where Professor Mollier, author of the steam tables and the Total Heat-Entropy diagram which bear his name, escorted the visitors through his department. Interesting work upon heat interchange between an exploded charge of gas and the metal of the containing vessel involving the determination of the specific heat at constant volume were in progress. Another interesting feature was an engine provided with a delicate apparatus at every working bearing to indicate and analyze knocks. We hope to be able to treat these researches more fully later. Other points of attraction were the local industries, the picture gallery and the Green Vault where the crown jewels are displayed. The visit to Dresden ended all too quickly with a luncheon tendered by the local division of the Verein and at 2:30 the party took its special train for Berlin.

TWO SIDES OF THE MEDAL STRUCK IN COMMEMORATION OF THE MEETING

AT BERLIN

To do Berlin in two days was beyond the power even of this now some experienced group, but it made a frantic try at it. In a little over two hours after the train reached the city the visitors were at a reception in the Palace of the Imperial Diet. Friday and Saturday they visited many of the local industries and the Royal Technical High School at Charlottenberg. Saturday afternoon they were taken in automobiles for a drive over the famous Heerstrasse to Wannsee, given a steamer trip on the Havel, and a farewell supper in the Swedish Pavilion at Wannsee.

AT DUSSELDORF

It is an all-day ride from Berlin to Düsseldorf, the next stopping place. The party arrived there late on Sunday afternoon and was given a reception in the Tonhalle by the city of Düsseldorf at which Dr. Frohlich, secretary of the Vereins deutscher Maschinenbau-Anst, read a paper upon the "Rhenish-Westfalian Industries," illustrated by lantern slides. This was followed by an opportunity for social intercourse with the refreshments without which no occasion here is complete.

Monday was devoted to visiting various industries and an inspection of the harbor, with a banquet in the evening given by the Rhenish-Westfalian Committee of the Verein. The feature of the evening was an allegorical play in which a huge billet of red-hot steel was flattened out under the forge press and when turned up revealed the emblems of the Verein Deutscher Ingenieure and the American Society of Mechanical Engineers embedded in the apparently glowing metal.

Tuesday was again devoted to visiting industrial establishments by the men and to auto rides and visits to the art galleries by the ladies. A dainty lunch was served at the "Malkasten," an artists' club, and the party moved over to Cologne only an hour away in time to see something of the city and dress for the "Evening on the Rhine." The program announced that "Supper and fun" had been prepared by the Rhenish-Westfalian committee and there was no lack of either notwithstanding the cold and damp weather prevented them from being served upon the lawn as the feature of a regular Abend am Rhein should properly be. Particularly enjoyable was the singing by the Cölner Männergesangverein, a male chorus of over a hundred voices, which has held the emperor's prize for a number of years.

AT COLOGNE

On Wednesday an opportunity was afforded to visit the industries of Cologne and the vicinity, the museums, etc., and the cathedral, the ladies and gentlemen of the local committee acting personally as guides and interpreters. In the evening a reception and banquet was given by the city of Cologne in the historic old Gürzenich built by the city in 1441-1447 for festival and similar purposes, serving for the ceremonial receptions of the emperors Frederic III and Maximilian I in the 15th century, of Charles V in the 16th century, and an imperial diet of Maximilian in 1505 and the meeting of the Electors to choose King Ferdinand I in 1531.

AT FRANKFORT-ON-THE-MAIN

On Thursday the visitors started on their journey up the Rhine going by train to Corblenz, then by boat to Rüdesheim and thence by rail to Frankfort-on-the-Main, where they were received by the Frankfurter Bezirk Verein, Deutscher Ingenieure. The evening was spent in the Palm Garden, with feasting, music and special illumination.

At noon of Friday, the fourth, luncheon was given in the Römer by the city of Frankfort and an opportunity afforded to inspect this and the neighboring old Guild houses. In the afternoon the party divided into groups for the inspection of various shops and factories. In the evening the Americans became the hosts, inviting the officers of the city and the Verein and the committee to help them celebrate the national holiday with a banquet in the Kurhaus Bad Homburg.

AT MANNHEIM

On Saturday forenoon the party proceeded to Mannheim where it arrived in time for luncheon. After an afternoon of sightseeing among the works for the men and of receptions at the homes of the directors for the ladies, a banquet was given by the city of Mannheim in the Nibelungensaal of the Rosengarten in the evening, at which a picked chorus of 24 male voices was a specially enjoyable feature.

AT HEIDELBERG

Sunday was devoted to a visit to Heidelberg. The inspection of the castle was somewhat interfered with by the rain, which abated, however, in time to allow the party to go in open boats upon the Neckar and see the castle illuminated and an elaborate display of fireworks upon the bridge and river bank. Heidelberg had been a bright spot in a glittering program, and notwithstanding the unpropitious weather the expectations even of the most sanguine were fully satisfied.

BADGES GIVEN THE GUESTS AT HAMBURG, LEIPZIG AND MANNHEIM AND THE OFFICIAL A. S. M. E. BADGE

AT MUNICH

Monday, the seventh, was spent in getting to Munich where the trip ended. It would seem as though there were nothing left that man could do to sustain the interest of this much entertained crowd and provide new sensations of pleasure and enjoyment, but the Bavarians were equal to it, and their wel-

coming evening in the world-renowned Hofbräuhaus was so in keeping with the reputation of the place for good fellowship and camaraderie, so different from all that had gone before that the enthusiasm of the guests was aroused to a higher pitch than ever.

On Wednesday forenoon a visit was paid to the German Industrial Museum of which Oskar von Miller, also president of the Verein Deutscher Ingenieure, is the president. Lunch was served in the still uncompleted new building at which Past-President E. D. Meier presented the museum in the name of the American Society with the model of the Panama Canal which had been brought over for that purpose and Dr. von Miller responded by presenting the Society with an original telescope of Fraunhofer.

In the afternoon an excursion was made to the Lake of Starnberg and the closing ceremonies of the trip took place at a banquet given by the city of Munich in the old Town Hall.

A final assemblage of the party was held at the Regina Palast on Wednesday forenoon where resolutions of thanks were passed to all who had been concerned in their entertainment. Dr. Conrad Matschoss, the representative of the Verein Deutscher Ingenieure, who had visited America to convey the official invitation and arrange the preliminary details, and who had met the party at Plymouth and accompanied them throughout the trip was given a special demonstration and expressed the hope that the visit might result in the establishment of permanently pleasant relations between the engineers of the two participating nations. He also made a special plea for the preservation and record in America of the history of engineering and industry. The world's history as at present taught and accessible, recounts the reigns of kings and glorifies warriors and conquerors, but gives almost nothing of the work of the great inventors and promotors who have done more for the development of the race than those whose portraits fill the galleries and whose deeds have inspired historians, poets and painters. There should be an earnest concerted movement on the part of engineers to preserve the record of their work and impress the world with its meaning and importance. More of the veterans should record their experience as John Fritz and Charles T. Porter have done, and museums should be established, for the preservation of apparatus and machines of historical interest, and the demonstration by models of classical experiments and the development of various industries. He pleaded for the cooperation of all American engineers in the task which he has undertaken of putting the achievements of the engineer on record.

In the afternoon a visit was paid to the Technical High School where Dr. Knobloch, whose work with Jakob forms the basis of our latest knowledge of the properties of superheated steam, personally exhibited his laboratories and later Dr. Diesel received a large number of the visitors at his home.

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Explosion of Traction Boiler Fatal

A traction-boiler explosion near Alva, Okla., on July 8, killed one man and severely injured two others.

It is stated that the second-hand traction engine was at least 20 years old, and that none of its type had been made in 15 years. At the time of the explosion the boiler was carrying 165 lb. pressure, but how long it had been thus subjected is unknown. A day before the accident the fusible plug blew out and an iron pipe plug is said to have been inserted.

The man who attended the tractor and thrasher quit his job a few days prior to the explosion because of the unsafe condition of the boiler. He also advised the owner to reduce the pressure.

About a year ago the flue bagged considerably and the owner took the machine to the Alva Machine Works for repair. The manager of the works refused to repair it, stating that the machine was so weak and dangerous as to be fit only for the junk pile. The owner later pushed the bag back with a screw jack while the metal was cold. The flue gave way at the edges of the metal where the bag was forced back. The man who was killed was blown 180 ft., and his body terribly mangled.

The illustrations show how the machine was damaged.

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Minnesota State N. A. S. E. Convention

The fourth annual convention of the Minnesota State Association of the National Association of Stationary Engineers was held in Duluth on July 16, 17 and 18. Both the business sessions and the exhibit were held in the Spalding Hotel.

Mayor W. I. Prince welcomed the delegates and visitors to Duluth at the opening session on Wednesday morning, and T. W. Hugo, Duluth, responded in the absence of National President John F. McGrath, who was delayed one day in arriving. State President J. B. Crane then delivered his message in which he took up the subject of license laws for Minnesota.

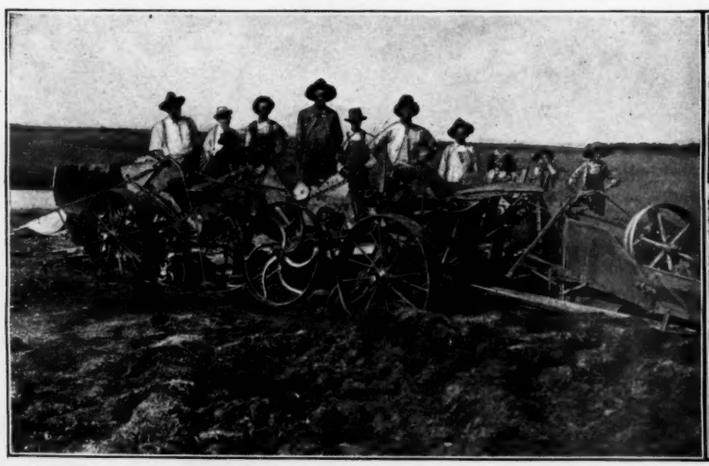
In the afternoon a boat trip was taken on the St. Louis River in a boat furnished by the Duluth Commercial Club. At the evening session various committee reports were submitted and Whitney Wall, of Duluth, gave a lecture on "Building Management and the Engineer."

On Thursday morning National President McGrath addressed the convention, devoting his remarks principally to the ways and means of securing desired license legislation. He thought much could be done by making clear the objects of license laws to all affected or interested. Emphasis was laid upon the need of diplomacy. In concluding he briefly reviewed the progress made during the last year by the national body.

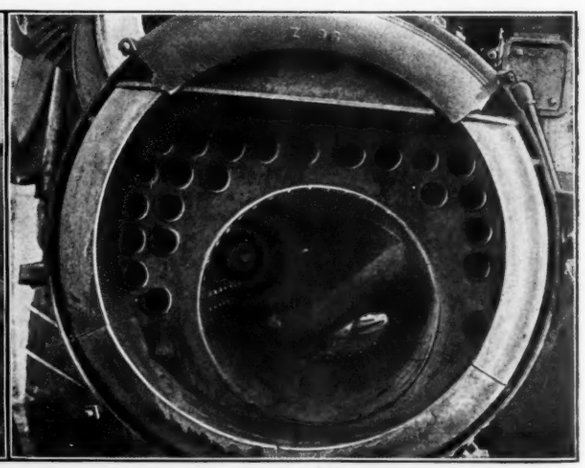
State President Crane offered a prize last year of $25 for the best paper prepared and presented at this convention. Although only two papers were entered, these brought out so much interest and discussion that the scheme was considered a decided success.

Association No. 4, Winona, entered a paper on "Heating and Ventilating." This paper was printed and copies were issued to all present. The paper discussed three systems of heating employed in large buildings, namely, direct, direct-indirect and indirect. In addition, a method of calculating the required amount of radiating surface for a given set of conditions was presented as well as the commonly employed factors for various kinds of walls and surfaces.

The paper concluded with a brief review of the requirements for proper ventilation and some data were given as to fan capacities.



WRECK OF THE TRACTION ENGINE



WHERE THE BOILER FAILED

The other paper was submitted by Association No. 7 of St. Paul, and was on the topic of "The Isolated Plant versus Central Station." The paper showed that where a private plant is installed that is capable of producing current cheaper than current can be purchased the fixed charges are not such a serious item as sometimes believed. To illustrate this point. two plants under identical conditions were compared. In one case the plant was designed to generate current and heat with the exhaust steam. In the other, current was purchased and the heating was done with live steam.

The cost of light, heat and power in the first case was $4395, and in the second $6800 per year, showing a saving of $2400 per year in favor of the isolated plant. Now if this annual saving were invested each year for 20 years at 5 per cent. interest, at the end of that period there would be a credit in favor of the isolated plant of about $67,000. If the original equipment cost $13,900, the plant could be entirely renewed, if necessary, and there still would be a clear balance of $53,100.

In view of the practically equal merits of the two papers and the large amount of interest and discussion occasioned by both, it was decided to split the prize and award half to each association.

On Thursday afternoon another boat trip was taken, during which visits were paid to the coal docks of the Northwestern Fuel Co., the plant of the American Carbolite Co. and the blast furnace of the Zenith Furnace Co.

In the evening a smoker was given by the Central States Exhibitors' Association in the exhibit hall, Mayor Prince, of Duluth, Mayor Keller, of St. Paul, and National President McGrath made brief addresses after which a special meeting of the subordinate association of engineers in Duluth was held for the purpose of electing these distinguished guests to honorary membership. The meeting was then immediately adjourned, and the lighter part of the program taken up.

At the Friday morning session a resolution was passed favoring biennial national conventions and the following officers were elected: H. F. Mueller, Minneapolis, president; F. H. Kirchner, Winona, vice-president; James McGeary, St. Paul, reëlected secretary; J. Albert Johnson, St. Paul, reëlected treasurer; E. F. Voss, Duluth, trustee.

The next annual convention will be held in Minneapolis.

The Central States Exhibitors' Association held its annual election on Friday morning with the following results: Charles Cullen, president; C. H. Fiske, secretary-treasurer; executive committee; W. L. Osborne, S. E. Denney, Fred Brunner, H. R. Anness, E. J. Kuchenmeister, A. J. Richardson and A. J. Beckerleg; state vice-presidents, Minnesota, H. A. Burdorf; Wisconsin, E. T. Ward; Iowa, J. H. Williamson; Illinois, A. J. Olson; Indiana, C. S. Kiessling; Kentucky, A. H. Reuter; Missouri, Joseph Deady, and Ohio, J. G. Boyer.

Grashof Medal Award

The award of the Grashof medal to George Westinghouse by the Verein Deutscher Ingenieure has aroused interest as to this medal and its significance. It can only be awarded for scientific or practical service in the realm of engineering. Its award to Mr. Westinghouse upon the occasion of the visit of so many American engineers is not, therefore, as was forcibly pointed out at the time of its bestowal, to be taken as a compliment to the American Society or to American engineers in general, but as a recognition of the work of the recipient as an engineer for the good of humanity.

The Grashof medal is 5 cm. (nearly 2 in.) in diameter, of gold, carrying upon one side the head of Franz Grashof, surrounded by a wreath, and on the other the name of the recipient and the date of its bestowal with the inscription "Grashof-Denkmünze des Vereines deutscher Ingeneures." It is awarded by the governing bodies of the Verein with the approval of living former recipients. It has previously been awarded to: C. von Bach, H. Gruson, O. Intze, F. Schisau, Gustav Zeuner, A. Wöhler, G. von Krauss, Carl von Linde, A. Riedler, Hugo Luther, A. von Rieppel, Heinrich Sulzer-Steiner, Justus Flohr, A. Slaby, Gustaf de Laval, Charles A. Parsons, Max von Eyth, Herman Blohm, E. Rathenau, Aurel Stodola, Ferdinand von Zeppelin, Ernst Körting, Carl H. Ziese, A. Martens, and Paul Mauser.

A Group of N. A. S. E. Delegates and Visitors at the Minnesota Convention

PERSONALS

Louis Streng, formerly chief engineer of the Kentucky Electric Co., Louisville, Ky., has been retained as consulting engineer by the Louisville Gas & Electric Co.

C. A. Orr, formerly chief engineer and master mechanic of the John Morrell & Co. packing plant, Ottumwa, Ia., has accepted the position of superintendent of power house and shops of the Arkansas River Valley Ry., Light & Power Co., Pueblo, Colo.

George M. Brill, M. Am. Soc. M. E., has retired from the firm of Brill & Gardner, engineers, 1134 Marquette Bldg., Chicago, Ill., and the partnership has been dissolved. Mr. Brill is at present in Germany with the visiting party of the American Society of Mechanical Engineers and will continue to spend some time in travel and study in Europe before returning to this country. The business of the firm will continue under its present name.

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